**Chapter 7 Special Conditions**

Article 700 Emergency Systems

Part I General

700.1 Scope

This article applies to the electrical safety of the installation, operation, and maintenance of emergency systems consisting of circuits and equipment intended to supply, distribute, and control electricity for illumination, power, or both, to required facilities when the normal electrical supply or system is interrupted.

Informational Note No. 1: For further information regarding wiring and installation of emergency systems in health care facilities, see Article 517.

Informational Note No. 2: For further information regarding performance and maintenance of emergency systems in health care facilities, see NFPA 99-2018, Health Care Facilities Code.

Informational Note No. 3: For specification of locations where emergency lighting is considered essential to life safety, see NFPA 101-2018, Life Safety Code.

Informational Note No. 4: For further information regarding performance of emergency and standby power systems, see NFPA 110-2019, Standard for Emergency and Standby Power Systems.

700.2 Definitions

Branch-Circuit Emergency Lighting Transfer Switch. This definition shall apply only within this article.

A device connected on the load side of a branch-circuit overcurrent protective device that transfers only emergency lighting loads from the normal supply to an emergency supply.

Informational Note: See ANSI/UL 1008, Transfer Switch Equipment, for information covering branch-circuit emergency lighting transfer switches.

Emergency Luminaire, Directly Controlled. An emergency luminaire that has a control input for an integral dimming or switching function that drives the luminaire to the required illumination level upon loss of normal power.

Informational Note: See ANSI/UL 924, Emergency Lighting and Power Equipment, for information covering directly controlled luminaires.

Emergency Systems. This definition shall apply within this article and throughout the Code.

Those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction. These systems are intended to automatically supply illumination, power, or both, to designated areas and equipment in the event of failure of the normal supply or in the event of accident to elements of a system intended to supply, distribute, and control power and illumination essential for safety to human life.

Informational Note: Emergency systems are generally installed in places of assembly where artificial illumination is required for safe exiting and for panic control in buildings subject to occupancy by large numbers of persons, such as hotels, theaters, sports arenas, health care facilities, and similar institutions. Emergency systems may also provide power for such functions as ventilation where essential to maintain life, fire detection and alarm systems, elevators, fire pumps, public safety communications systems, industrial processes where current interruption would produce serious life safety or health hazards, and similar functions.

Relay, Automatic Load Control. A device used to set normally dimmed or normally-off switched emergency lighting equipment to full power illumination levels in the event of a loss of the normal supply by bypassing the dimming/switching controls, and to return the emergency lighting equipment to normal status when the device senses the normal supply has been restored.

Informational Note: See ANSI/UL 924, Emergency Lighting and Power Equipment, for the requirements covering automatic load control relays.

700.3 Tests and Maintenance

(A) Conduct or Witness Test

The authority having jurisdiction shall conduct or witness a test of the complete system upon installation and periodically afterward.

(B) Tested Periodically

Systems shall be tested periodically on a schedule approved by the authority having jurisdiction to ensure the systems are maintained in proper operating condition.

(C) Maintenance

Emergency system equipment shall be maintained in accordance with manufacturer instructions and industry standards.

(D) Written Record

A written record shall be kept of such tests and maintenance.

(E) Testing Under Load

Means for testing all emergency lighting and power systems during maximum anticipated load conditions shall be provided.

Informational Note: For information on testing and maintenance of emergency power supply systems (EPSSs), see NFPA 110-2019, Standard for Emergency and Standby Power Systems.

(F) Temporary Source of Power for Maintenance or Repair of the Alternate Source of Power

If the emergency system relies on a single alternate source of power, which will be disabled for maintenance or repair, the emergency system shall include permanent switching means to connect a portable or temporary alternate source of power, which shall be available for the duration of the maintenance or repair. The permanent switching means to connect a portable or temporary alternate source of power shall comply with the following:

Connection to the portable or temporary alternate source of power shall not require modification of the permanent system wiring.

Transfer of power between the normal power source and the emergency power source shall be in accordance with 700.12.

The connection point for the portable or temporary alternate source shall be marked with the phase rotation and system bonding requirements.

Mechanical or electrical interlocking shall prevent inadvertent interconnection of power sources.

The switching means shall include a contact point that shall annunciate at a location remote from the generator or at another facility monitoring system to indicate that the permanent emergency source is disconnected from the emergency system.

It shall be permissible to utilize manual switching to switch from the permanent source of power to the portable or temporary alternate source of power and to utilize the switching means for connection of a load bank.

Informational Note: There are many possible methods to achieve the requirements of 700.3(F). See Informational Note Figure 700.3(F) for one example.

Exception: The permanent switching means to connect a portable or temporary alternate source of power, for the duration of the maintenance or repair, shall not be required where any of the following conditions exists:

All processes that rely on the emergency system source are capable of being disabled during maintenance or repair of the emergency source of power.

The building or structure is unoccupied and fire protection systems are fully functional and do not require an alternate power source.

Other temporary means can be substituted for the emergency system.

A permanent alternate emergency source, such as, but not limited to, a second on-site standby generator or separate electric utility service connection, capable of supporting the emergency system, exists.

Informational Note Figure 700.3(F)

700.4 Capacity and Rating

(A) Rating

The emergency system equipment shall be suitable for the available fault current at its terminals.

(B) Capacity

An emergency system shall have adequate capacity in accordance with Article 220 or by another approved method.

(C) Selective Load Pickup, Load Shedding, and Peak Load Shaving

The alternate power source shall be permitted to supply emergency, legally required standby, and optional standby system loads where the source has adequate capacity or where automatic selective load pickup and load shedding is provided as needed to ensure adequate power to (1) the emergency circuits, (2) the legally required standby circuits, and (3) the optional standby circuits, in that order of priority. The alternate power source shall be permitted to be used for peak load shaving, provided these conditions are met.

Peak load shaving operation shall be permitted for satisfying the test requirement of 700.3(B), provided all other conditions of 700.3 are met.

700.5 Transfer Equipment

(A) General

Transfer equipment shall be automatic, listed, and marked for emergency use, and approved by the authority having jurisdiction. Transfer equipment shall be designed and installed to prevent the inadvertent interconnection of normal and emergency sources of supply in any operation of the transfer equipment. Transfer equipment and electric power production systems installed to permit operation in parallel with the normal source shall meet the requirements of Article 705. Meter-mounted transfer switches shall not be permitted for emergency system use.

(B) Bypass Isolation Switches

Means shall be permitted to bypass and isolate the transfer equipment. Where bypass isolation switches are used, inadvertent parallel operation shall be avoided.

(C) Automatic Transfer Switches

Automatic transfer switches shall be electrically operated and mechanically held. Automatic transfer switches shall not be permitted to be reconditioned.

(D) Use

Transfer equipment shall supply only emergency loads.

(E) Documentation

The short-circuit current rating of the transfer equipment, based on the specific overcurrent protective device type and settings protecting the transfer equipment, shall be field marked on the exterior of the transfer equipment.

700.6 Signals

Audible and visual signal devices shall be provided, where practicable, for the purpose described in 700.6(A) through (D).

(A) Malfunction

To indicate malfunction of the emergency source.

(B) Carrying Load

To indicate that the emergency source is carrying load.

(C) Not Functioning

To indicate that the battery charger is not functioning.

(D) Ground Fault

To indicate a ground fault in solidly grounded wye emergency systems of more than 150 volts to ground and circuit-protective devices rated 1000 amperes or more. The sensor for the ground-fault signal devices shall be located at, or ahead of, the main system disconnecting means for the emergency source, and the maximum setting of the signal devices shall be for a ground-fault current of 1200 amperes. Instructions on the course of action to be taken in the event of indicated ground fault shall be located at or near the sensor location.

For systems with multiple emergency sources connected to a paralleling bus, the ground fault sensor and the system bonding jumper shall be permitted to be at an alternative location.

700.7 Signs

(A) Emergency Sources

A sign shall be placed at the service-entrance equipment, indicating type and location of each onsite emergency power source.

Exception: A sign shall not be required for individual unit equipment as specified in 700.12(I).

(B) Grounding

Where removal of a grounding or bonding connection in normal power source equipment interrupts the grounding electrode conductor connection to the alternate power source(s) grounded conductor, a warning sign shall be installed at the normal power source equipment stating:

WARNING

SHOCK HAZARD EXISTS IF GROUNDING ELECTRODE CONDUCTOR OR BONDING JUMPER CONNECTION IN THIS EQUIPMENT IS REMOVED WHILE ALTERNATE SOURCE(S) IS ENERGIZED.

The warning sign(s) or label(s) shall comply with 110.21(B).

700.8 Surge Protection

A listed SPD shall be installed in or on all emergency systems switchboards and panelboards.

Part II Circuit Wiring

700.10 Wiring, Emergency System

(A) Identification

Emergency circuits shall be permanently marked so they will be readily identified as a component of an emergency circuit or system by the following methods:

All boxes and enclosures (including transfer switches, generators, and power panels) for emergency circuits shall be permanently marked as a component of an emergency circuit or system.

Where boxes or enclosures are not encountered, exposed cable or raceway systems shall be permanently marked to be identified as a component of an emergency circuit or system, at intervals not to exceed 7.6 m (25 ft).

Receptacles supplied from the emergency system shall have a distinctive color or marking on the receptacle cover plates or the receptacles.

(B) Wiring

Wiring from an emergency source or emergency source distribution overcurrent protection to emergency loads shall be kept entirely independent of all other wiring and equipment unless otherwise permitted in 700.10(B)(1) through (B)(5):

Wiring from the normal power source located in transfer equipment enclosures

Wiring supplied from two sources in exit or emergency luminaires

Wiring from two sources in a listed load control relay supplying exit or emergency luminaires, or in a common junction box, attached to exit or emergency luminaires

Wiring within a common junction box attached to unit equipment, containing only the branch circuit supplying the unit equipment and the emergency circuit supplied by the unit equipment

Wiring from an emergency source to supply emergency and other (nonemergency) loads in accordance with 700.10(B)(5)a., (B)(5)b., (B)(5)c., and (B)(5)d. as follows:

Separate vertical switchgear sections or separate vertical switchboard sections, with or without a common bus, or individual disconnects mounted in separate enclosures shall be used to separate emergency loads from all other loads.

The common bus of separate sections of the switchgear, separate sections of the switchboard, or the individual enclosures shall be either of the following:

Supplied by single or multiple feeders without overcurrent protection at the source

Supplied by single or multiple feeders with overcurrent protection, provided that the overcurrent protection that is common to an emergency system and any nonemergency system(s) is selectively coordinated with the next downstream overcurrent protective device in the nonemergency system(s)

Informational Note: For further information, see Informational Note Figure 700.10(B)(a) and Informational Note Figure 700.10(B)(b).

Emergency circuits shall not originate from the same vertical switchgear section, vertical switchboard section, panelboard enclosure, or individual disconnect enclosure as other circuits.

It shall be permissible to utilize single or multiple feeders to supply distribution equipment between an emergency source and the point where the emergency loads are separated from all other loads.

Wiring of two or more emergency circuits supplied from the same source shall be permitted in the same raceway, cable, box, or cabinet.

Informational Note Figure 700.10(B)(a) Single or Multiple Feeders Without Overcurrent Protection.

Informational Note Figure 700.10(B)(b) Single or Multiple Feeders with Overcurrent Protection.

(C) Wiring Design and Location

Emergency wiring circuits shall be designed and located so as to minimize the hazards that might cause failure due to flooding, fire, icing, vandalism, and other adverse conditions.

(D) Fire Protection

(1) Occupancies

Emergency systems shall meet the additional requirements in 700.10(D)(2) through (D)(4) in the following occupancies:

Assembly occupancies for not less than 1000 persons

Buildings above 23 m (75 ft) in height

Educational occupancies with more than 300 occupants

(2) Feeder-Circuit Wiring

Feeder-circuit wiring shall meet one of the following conditions:

The cable or raceway is installed in spaces or areas that are fully protected by an approved automatic fire protection system.

The cable or raceway is protected by a listed electrical circuit protective system with a minimum 2-hour fire rating.

Informational Note No. 1: Electrical circuit protective systems could include but not be limited to thermal barriers or a protective shaft and are tested to UL 1724, Fire Tests for Electrical Circuit Protection Systems.

Informational Note No. 2: The listing organization provides information for electrical circuit protective systems on proper installation requirements to maintain the fire rating.

The cable or raceway is a listed fire-resistive cable system with a minimum 2-hour fire rating.

Informational Note No. 1: Fire-resistive cables are tested to ANSI/UL 2196-2017, Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control and Data Cables.

Informational Note No. 2: The listing organization provides information for fire-resistive cable systems on proper installation requirements to maintain the fire rating.

The cable or raceway is protected by a listed fire-rated assembly that has a minimum fire rating of 2 hours and contains only emergency circuits.

The cable or raceway is encased in a minimum of 50 mm (2 in.) of concrete.

(3) Feeder-Circuit Equipment

Equipment for feeder circuits (including transfer switches, transformers, and panelboards) shall be located either in spaces fully protected by an approved automatic fire protection system or in spaces with a 2-hour fire resistance rating.

(4) Generator Control Wiring

Control conductors installed between the transfer equipment and the emergency generator shall be kept entirely independent of all other wiring and shall meet the conditions of 700.10(D)(2). The integrity of the generator remote start circuit shall be monitored for broken, disconnected, or shorted wires. Loss of integrity shall start the generator(s).

Part III Sources of Power

700.12 General Requirements

Current supply shall be such that, in the event of failure of the normal supply to, or within, the building or group of buildings concerned, emergency lighting, emergency power, or both shall be available within the time required for the application but not to exceed 10 seconds. The supply system for emergency purposes, in addition to the normal services to the building and meeting the general requirements of this section, shall be one or more of the types of systems described in 700.12(C) through (H). Unit equipment in accordance with 700.12(I) shall satisfy the applicable requirements of this article.

(A) Power Source Considerations

In selecting an emergency source of power, consideration shall be given to the occupancy and the type of service to be rendered, whether of minimum duration, as for evacuation of a theater, or longer duration, as for supplying emergency power and lighting due to an indefinite period of current failure from trouble either inside or outside the building.

(B) Equipment Design and Location

Equipment shall be designed and located so as to minimize the hazards that might cause complete failure due to flooding, fires, icing, and vandalism.

Equipment for sources of power as described in 700.12(C) through (H) shall be installed either in spaces fully protected by approved automatic fire protection systems or in spaces with a 2-hour fire rating where located within the following:

Assembly occupancies for more than 1000 persons

Buildings above 23 m (75 ft) in height with any of the following occupancy classes — assembly, educational, residential, detention and correctional, business, and mercantile

Educational occupancies with more than 300 occupants

Informational Note No. 1: For the definition of Occupancy Classification, see Section 6.1 of NFPA 101-2018, Life Safety Code.

Informational Note No. 2: For information regarding power system reliability, see IEEE 3006.5-2014, Recommended Practice for the Use of Probability Methods for Conducting a Reliability Analysis of Industrial and Commercial Power Systems.

(C) Storage Battery

Storage batteries shall be of suitable rating and capacity to supply and maintain the total load for a minimum period of 11/2 hours, without the voltage applied to the load falling below 871/2 percent of normal. Automotive-type batteries shall not be used.

An automatic battery charging means shall be provided.

(D) Generator Set

(1) Prime Mover-Driven

For a generator set driven by a prime mover approved by the authority having jurisdiction and sized in accordance with 700.4, means shall be provided for automatically starting the prime mover on failure of the normal service and for automatic transfer and operation of all required electrical circuits. A time-delay feature shall be provided to avoid retransfer in case of short-time reestablishment of the normal source.

(2) Internal Combustion Engines as Prime Movers

(a) On-Site Fuel Supply. Where internal combustion engines are used as the prime mover, an on-site fuel supply shall be provided with an on-premises fuel supply sufficient for not less than 2 hours' operation of the system.

(b) Fuel Transfer Pumps. Where power is needed for the operation of the fuel transfer pumps to deliver fuel to a generator set day tank, this pump shall be connected to the emergency power system.

(c) Public Gas System, Municipal Water Supply. Prime movers shall not be solely dependent on a public utility gas system for their fuel supply or municipal water supply for their cooling systems.

Exception: Where approved by the authority having jurisdiction, the use of other than on-site fuels shall be permitted where there is a low probability of a simultaneous failure, of both the off-site, fuel delivery system and power from the outside electrical utility company.

(d) Automatic Fuel Transfer. Where dual fuel supplies are used, means shall be provided for automatically transferring from one fuel supply to another.

(3) Battery Power and Dampers

Where a storage battery is used for control or signal power or as the means of starting the prime mover, it shall be suitable for the purpose and shall be equipped with an automatic charging means independent of the generator set. Where the battery charger is required for the operation of the generator set, it shall be connected to the emergency system. Where power is required for the operation of dampers used to ventilate the generator set, the dampers shall be connected to the emergency system.

(4) Auxiliary Power Supply

Generator sets that require more than 10 seconds to develop power shall be permitted if an auxiliary power supply energizes the emergency system until the generator can pick up the load.

(5) Outdoor Generator Sets

Where an outdoor-housed generator set is equipped with a readily accessible disconnecting means in accordance with 445.18, and the disconnecting means is located within sight of the building or structure supplied, an additional disconnecting means shall not be required where ungrounded conductors serve or pass through the building or structure. Where the generator supply conductors terminate at a disconnecting means in or on a building or structure, the disconnecting means shall meet the requirements of 225.36.

Exception: For installations under single management, where conditions of maintenance and supervision ensure that only qualified persons will monitor and service the installation and where documented safe switching procedures are established and maintained for disconnection, the generator set disconnecting means shall not be required to be located within sight of the building or structure served.

(E) Uninterruptible Power Supplies

Uninterruptible power supplies used to provide power for emergency systems shall comply with the applicable provisions of 700.12(B) and (C).

(F) Separate Service

Where approved by the authority having jurisdiction as suitable for use as an emergency source of power, an additional service shall be permitted. This service shall be in accordance with the applicable provisions of Article 230 and the following additional requirements:

Separate overhead service conductors, service drops, underground service conductors, or service laterals shall be installed.

The service conductors for the separate service shall be installed sufficiently remote electrically and physically from any other service conductors to minimize the possibility of simultaneous interruption of supply.

(G) Fuel Cell System

Fuel cell systems used as a source of power for emergency systems shall be of suitable rating and capacity to supply and maintain the total load for not less than 2 hours of full-demand operation.

Installation of a fuel cell system shall meet the requirements of Parts II through VIII of Article 692.

Where a single fuel cell system serves as the normal supply for the building or group of buildings concerned, it shall not serve as the sole source of power for the emergency standby system.

(H) DC Microgrid Systems

Sources connected to a dc microgrid system shall be permitted where the system is capable of being isolated from all non-emergency sources.

DC microgrid systems used as a source of power for emergency systems shall be of suitable rating and capacity to supply and maintain the total emergency load for not less than 2 hours of full-demand operation.

Where a dc microgrid system source serves as the normal supply for the building or group of buildings concerned, it shall not serve as the sole source of power for the emergency standby system.

(I) Unit Equipment

(1) Components of Unit Equipment

Individual unit equipment for emergency illumination shall consist of the following:

A rechargeable battery

A battery charging means

Provisions for one or more lamps mounted on the equipment, or shall be permitted to have terminals for remote lamps, or both

A relaying device arranged to energize the lamps automatically upon failure of the supply to the unit equipment

(2) Installation of Unit Equipment

Unit equipment shall be installed in accordance with the following:

The batteries shall be of suitable rating and capacity to supply and maintain the total lamp load associated with the unit in accordance with the following:

For a period of at least 11/2 hours without the voltage falling below 871/2 percent of normal battery voltage.

The unit equipment shall supply and maintain not less than 60 percent of the initial emergency illumination for a period of at least 11/2 hours.

Unit equipment shall be permanently fixed (i.e., not portable) in place and shall have all wiring to each unit installed in accordance with the requirements of any of the wiring methods in Chapter 3. Flexible cord-and-plug connection shall be permitted, provided that the cord does not exceed 900 mm (3 ft) in length.

The branch circuit feeding the unit equipment shall be one of the following:

The same branch circuit as that serving the normal lighting in the area and connected ahead of any local switches

Where the normal lighting circuit is served by one or more branch circuits, a separate branch circuit, provided with a lock-on feature, that originates from the same panelboard as the normal lighting circuits. The branch circuit disconnecting means for this branch circuit shall be provided with a lock-on feature.

The branch circuit that feeds unit equipment shall be clearly identified at the distribution panel.

Emergency luminaires that obtain power from a unit equipment and are not part of the unit equipment shall be wired to the unit equipment as required by 700.10 and by one of the wiring methods of Chapter 3.

Remote heads providing lighting for the exterior of an exit door shall be permitted to be supplied by the unit equipment serving the area immediately inside the exit door.

Part IV Emergency System Circuits for Lighting and Power

700.15 Loads on Emergency Branch Circuits

No appliances and no lamps, other than those specified as required for emergency use, shall be supplied by emergency lighting circuits.

700.16 Emergency Illumination

(A) General

Emergency illumination shall include means of egress lighting, illuminated exit signs, and all other luminaires specified as necessary to provide required illumination.

Upcodes Diagrams

(B) System Reliability

Emergency lighting systems shall be designed and installed so that the failure of any illumination source cannot leave in total darkness any space that requires emergency illumination. Control devices in the emergency lighting system shall be listed for use in emergency systems. Listed unit equipment in accordance with 700.12(I) shall be considered as meeting the provisions of this section.

Informational Note: 700.23 through 700.26 provide requirements for applications of emergency system control devices.

(C) Discharge Lighting

Where high-intensity discharge lighting such as high- and low-pressure sodium, mercury vapor, and metal halide is used as the sole source of normal illumination, the emergency lighting system shall be required to operate until normal illumination has been restored.

(D) Disconnecting Means

Where an emergency system is installed, emergency illumination shall be provided in the area of the disconnecting means required by 225.31 and 230.70, as applicable, where the disconnecting means are installed indoors.

Exception: Alternative means that ensure that the emergency lighting illumination level is maintained shall be permitted.

700.17 Branch Circuits for Emergency Lighting

Branch circuits that supply emergency lighting shall be installed to provide service from a source complying with 700.12 when the normal supply for lighting is interrupted. Such installations shall provide either of the following:

An emergency lighting supply, independent of the normal lighting supply, with provisions for automatically transferring the emergency lights upon the event of failure of the normal lighting branch circuit

Two or more branch circuits supplied from separate and complete systems with independent power sources. One of the two power sources and systems shall be part of the emergency system, and the other shall be permitted to be part of the normal power source and system. Each system shall provide sufficient power for emergency lighting purposes.

Unless both systems are used for regular lighting purposes and are both kept lighted, means shall be provided for automatically energizing either system upon failure of the other. Either or both systems shall be permitted to be a part of the general lighting of the protected occupancy if circuits supplying lights for emergency illumination are installed in accordance with other sections of this article.

700.18 Circuits for Emergency Power

For branch circuits that supply equipment classed as emergency, there shall be an emergency supply source to which the load will be transferred automatically upon the failure of the normal supply.

700.19 Multiwire Branch Circuits

The branch circuit serving emergency lighting and power circuits shall not be part of a multiwire branch circuit.

Part V Control — Emergency Lighting Circuits

700.20 Switch Requirements

The switch or switches installed in emergency lighting circuits shall be arranged so that only authorized persons have control of emergency lighting.

Exception No. 1: Where two or more single-throw switches are connected in parallel to control a single circuit, at least one of these switches shall be accessible only to authorized persons.

Exception No. 2: Additional switches that act only to put emergency lights into operation but not disconnect them shall be permissible.

Switches connected in series or 3- and 4-way switches shall not be used.

700.21 Switch Location

All manual switches for controlling emergency circuits shall be in locations convenient to authorized persons responsible for their actuation. In facilities covered by Articles 518 and 520, a switch for controlling emergency lighting systems shall be located in the lobby or at a place conveniently accessible thereto.

In no case shall a control switch for emergency lighting be placed in a motion-picture projection booth or on a stage or platform.

Exception: Where multiple switches are provided, one such switch shall be permitted in such locations where arranged so that it can only energize the circuit but cannot de-energize the circuit.

700.22 Exterior Lights

Those lights on the exterior of a building that are not required for illumination when there is sufficient daylight shall be permitted to be controlled by an automatic light-actuated device.

700.23 Dimmer and Relay Systems

A dimmer or relay system containing more than one dimmer or relay and listed for use in emergency systems shall be permitted to be used as a control device for energizing emergency lighting circuits. Upon failure of normal power, the dimmer or relay system shall be permitted to selectively energize only those branch circuits required to provide minimum emergency illumination using a control bypass function. Where the dimmer or relay system is fed by a normal/emergency source from an upstream transfer switch, normal power sensing for this function shall be permitted to be from a normal-only power source upstream of the transfer switch. All branch circuits supplied by the dimmer or relay system cabinet shall comply with the wiring methods of Article 700.

700.24 Directly Controlled Emergency Luminaires

Where emergency illumination is provided by one or more directly controlled emergency luminaires that respond to an external control input, or loss thereof, to bypass normal control upon loss of normal power, such luminaires and external bypass controls shall be individually listed for use in emergency systems.

700.25 Branch Circuit Emergency Lighting Transfer Switch

Emergency lighting loads supplied by branch circuits rated at not greater than 20 amperes shall be permitted to be transferred from the normal branch circuit to an emergency branch circuit using a listed branch circuit emergency lighting transfer switch. The mechanically held requirement of 700.5(C) shall not apply to listed branch circuit emergency lighting transfer switches.

700.26 Automatic Load Control Relay

If an emergency lighting load is automatically energized upon loss of the normal supply, a listed automatic load control relay shall be permitted to energize the load. The load control relay shall not be used as transfer equipment.

Part VI Overcurrent Protection

700.30 Accessibility

The branch-circuit overcurrent devices in emergency circuits shall be accessible to authorized persons only.

700.31 Ground-Fault Protection of Equipment

The alternate source for emergency systems shall not be required to provide ground-fault protection of equipment with automatic disconnecting means. Ground-fault indication at the emergency source shall be provided in accordance with 700.6(D) if ground-fault protection of equipment with automatic disconnecting means is not provided.

700.32 Selective Coordination

Emergency system(s) overcurrent devices shall be selectively coordinated with all supply-side overcurrent protective devices.

Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.

Exception: Selective coordination shall not be required between two overcurrent devices located in series if no loads are connected in parallel with the downstream device.

Informational Note: See Informational Note Figure 700.32 for an example of how emergency system overcurrent protective devices (OCPDs) selectively coordinate with all supply-side OCPDs.

OCPD D selectively coordinates with OCPDs C, F, E, B, and A.

OCPD C selectively coordinates with OCPDs F, E, B, and A.

OCPD F selectively coordinates with OCPD E.

OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not an emergency system OCPD.

Informational Note Figure 700.32 Emergency System Selective Coordination.

Article 701 Legally Required Standby Systems

Part I General

701.1 Scope

This article applies to the electrical safety of the installation, operation, and maintenance of legally required standby systems consisting of circuits and equipment intended to supply, distribute, and control electricity to required facilities for illumination or power, or both, when the normal electrical supply or system is interrupted.

The systems covered by this article consist only of those that are permanently installed in their entirety, including the power source.

Informational Note No. 1: For further information, see NFPA 99-2018, Health Care Facilities Code.

Informational Note No. 2: For further information regarding performance of emergency and standby power systems, see NFPA 110-2019, Standard for Emergency and Standby Power Systems.

Informational Note No. 3: For further information, see ANSI/IEEE 446-1995, Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications.

Upcodes Diagrams

701.2 Definition

The definition in this section shall apply within this article and throughout the Code.

Legally Required Standby Systems. Those systems required and so classed as legally required standby by municipal, state, federal, or other codes or by any governmental agency having jurisdiction. These systems are intended to automatically supply power to selected loads (other than those classed as emergency systems) in the event of failure of the normal source.

Informational Note: Legally required standby systems are typically installed to serve loads, such as heating and refrigeration systems, communications systems, ventilation and smoke removal systems, sewage disposal, lighting systems, and industrial processes, that, when stopped during any interruption of the normal electrical supply, could create hazards or hamper rescue or fire-fighting operations.

701.3 Tests and Maintenance

(A) Conduct or Witness Test

The authority having jurisdiction shall conduct or witness a test of the complete system upon installation.

(B) Tested Periodically

Systems shall be tested periodically on a schedule and in a manner approved by the authority having jurisdiction to ensure the systems are maintained in proper operating condition.

(C) Maintenance

Legally required standby system equipment shall be maintained in accordance with manufacturer instructions and industry standards.

(D) Written Record

A written record shall be kept on such tests and maintenance.

(E) Testing Under Load

Means for testing legally required standby systems under load shall be provided.

Informational Note: For information on testing and maintenance of emergency power supply systems (EPSSs), see NFPA 110-2019, Standard for Emergency and Standby Power Systems.

701.4 Capacity and Rating

(A) Rating

Legally required standby system equipment shall be suitable for the available fault current at its terminals.

(B) Capacity

A legally required standby system shall have adequate capacity in accordance with Article 220 or by another approved method.

(C) Load Pickup, Load Shedding, and Peak Load Shaving

The alternate power source shall be permitted to supply legally required standby and optional standby system loads where the alternate source has adequate capacity or where automatic selective load pickup and load shedding are provided that will ensure adequate power to the legally required standby circuits.

701.5 Transfer Equipment

(A) General

Transfer equipment shall be automatic, listed, and marked for emergency system or legally required standby use, and approved by the authority having jurisdiction. Transfer equipment shall be designed and installed to prevent the inadvertent interconnection of normal and alternate sources of supply in any operation of the transfer equipment. Transfer equipment and electric power production systems installed to permit operation in parallel with the normal source shall meet the requirements of Article 705. Meter-mounted transfer switches shall not be permitted for legally required system use.

(B) Bypass Isolation Switches

Means to bypass and isolate the transfer switch equipment shall be permitted. Where bypass isolation switches are used, inadvertent parallel operation shall be avoided.

(C) Automatic Transfer Switches

Automatic transfer switches shall be electrically operated and mechanically held. Automatic transfer switches shall not be permitted to be reconditioned.

(D) Documentation

The short-circuit current rating of the transfer equipment, based on the specific overcurrent protective device type and settings protecting the transfer equipment, shall be field marked on the exterior of the transfer equipment.

701.6 Signals

Audible and visual signal devices shall be provided, where practicable, for the purposes described in 701.6(A), (B), (C), and (D).

(A) Malfunction

To indicate malfunction of the standby source.

(B) Carrying Load

To indicate that the standby source is carrying load.

(C) Not Functioning

To indicate that the battery charger is not functioning.

Informational Note: For signals for generator sets, see NFPA 110-2016, Standard for Emergency and Standby Power Systems.

(D) Ground Fault

To indicate a ground fault in solidly grounded wye, legally required standby systems of more than 150 volts to ground and circuit-protective devices rated 1000 amperes or more. The sensor for the ground-fault signal devices shall be located at, or ahead of, the main system disconnecting means for the legally required standby source, and the maximum setting of the signal devices shall be for a ground-fault current of 1200 amperes. Instructions on the course of action to be taken in event of indicated ground fault shall be located at or near the sensor location.

For systems with multiple emergency sources connected to a paralleling bus, the ground fault sensor shall be permitted at an alternate location.

Informational Note: For signals for generator sets, see NFPA 110-2019, Standard for Emergency and Standby Power Systems.

701.7 Signs

(A) Mandated Standby

A sign shall be placed at the service entrance indicating type and location of each on-site legally required standby power source.

Exception: A sign shall not be required for individual unit equipment as specified in 701.12(J).

(B) Grounding

Where removal of a grounding or bonding connection in normal power source equipment interrupts the grounding electrode conductor connection to the alternate power source(s) grounded conductor, a warning sign shall be installed at the normal power source equipment stating:

WARNING

SHOCK HAZARD EXISTS IF GROUNDING ELECTRODE CONDUCTOR OR BONDING JUMPER CONNECTION IN THIS EQUIPMENT IS REMOVED WHILE ALTERNATE SOURCE(S) IS ENERGIZED.

The warning sign(s) or label(s) shall comply with 110.21(B).

Part II Circuit Wiring

701.10 Wiring Legally Required Standby Systems

The legally required standby system wiring shall be permitted to occupy the same raceways, cables, boxes, and cabinets with other general wiring.

Part III Sources of Power

701.12 General Requirements

Current supply shall be such that, in the event of failure of the normal supply to, or within, the building or group of buildings concerned, legally required standby power will be available within the time required for the application but not to exceed 60 seconds. The supply system for legally required standby purposes, in addition to the normal services to the building, shall be permitted to comprise one or more of the types of systems described in 701.12(A) through (I). Unit equipment in accordance with 701.12(J) shall satisfy the applicable requirements of this article.

(A) Power Source Considerations

In selecting a legally required standby source of power, consideration shall be given to the type of service to be rendered, whether of short-time duration or long duration.

(B) Equipment Design and Location

Consideration shall be given to the location or design, or both, of all equipment to minimize the hazards that might cause complete failure due to floods, fires, icing, and vandalism.

Informational Note: For further information, see ANSI/IEEE 493-2007, Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems.

(C) Storage Battery

Storage batteries shall be of suitable rating and capacity to supply and maintain the total load for a minimum period of 11/2 hours without the voltage applied to the load falling below 871/2 percent of normal. Automotive-type batteries shall not be used.

An automatic battery charging means shall be provided.

(D) Generator Set

(1) Prime Mover-Driven

For a generator set driven by a prime mover approved by the authority having jurisdiction and sized in accordance with 701.4, means shall be provided for automatically starting the prime mover upon failure of the normal service and for automatic transfer and operation of all required electrical circuits. A time-delay feature permitting a 15-minute setting shall be provided to avoid retransfer in case of short-time re-establishment of the normal source.

(2) Internal Combustion Engines as Prime Mover

Where internal combustion engines are used as the prime mover, an on-site fuel supply shall be provided with an on-premises fuel supply sufficient for not less than 2 hours of full-demand operation of the system. Where power is needed for the operation of the fuel transfer pumps to deliver fuel to a generator set day tank, the pumps shall be connected to the legally required standby power system.

(3) Public Gas System, Municipal Water Supply

Prime movers shall not be solely dependent on a public utility gas system for their fuel supply or on a municipal water supply for their cooling systems. Means shall be provided for automatically transferring one fuel supply to another where dual fuel supplies are used.

Exception: Where approved by the authority having jurisdiction, the use of other than on-site fuels shall be permitted where there is a low probability of a simultaneous failure of both the offsite fuel delivery system and power from the outside electrical utility company.

(4) Battery Power

Where a storage battery is used for control or signal power or as the means of starting the prime mover, it shall be suitable for the purpose and shall be equipped with an automatic charging means independent of the generator set.

(5) Outdoor Generator Sets

Where an outdoor-housed generator set is equipped with a readily accessible disconnecting means in accordance with 445.18, and the disconnecting means is located within sight of the building or structure supplied, an additional disconnecting means shall not be required where ungrounded conductors serve or pass through the building or structure. Where the generator supply conductors terminate at a disconnecting means in or on a building or structure, the disconnecting means shall meet the requirements of 225.36.

(E) Uninterruptible Power Supplies

Uninterruptible power supplies used to provide power for legally required standby systems shall comply with 701.12(B) and (C).

(F) Separate Service

Where approved, a separate service shall be permitted as a legally required source of standby power. This service shall be in accordance with Article 230, with a separate service drop or lateral or a separate set of overhead or underground service conductors sufficiently remote electrically and physically from any other service to minimize the possibility of simultaneous interruption of supply from an occurrence in another service.

(G) Connection Ahead of Service Disconnecting Means

Where approved by the authority having jurisdiction, connections located ahead of and not within the same cabinet, enclosure, vertical switchgear section, or vertical switchboard section as the service disconnecting means shall be permitted. The legally required standby service shall be sufficiently separated from the normal main service disconnecting means to minimize simultaneous interruption of supply through an occurrence within the building or groups of buildings served.

Informational Note: See 230.82 for equipment permitted on the supply side of a service disconnecting means.

(H) Fuel Cell System

Fuel cell systems used as a source of power for legally required standby systems shall be of suitable rating and capacity to supply and maintain the total load for not less than 2 hours of full-demand operation.

Installation of a fuel cell system shall meet the requirements of Parts II through VIII of Article 692.

Where a single fuel cell system serves as the normal supply for the building or group of buildings concerned, it shall not serve as the sole source of power for the legally required standby system.

(I) DC Microgrid Systems

Sources connected to a dc microgrid system shall be permitted where the system is capable of being isolated from all nonlegally required sources.

A dc microgrid system used as a source of power for legally required systems shall be of suitable rating and capacity to supply and maintain the total legally required load for not less than 2 hours of full-demand operation.

Where a dc microgrid system source serves as the normal supply for the building or group of buildings concerned, it shall not serve as the sole source of power for the legally required standby system.

(J) Unit Equipment

Individual unit equipment for legally required standby illumination shall consist of the following:

A rechargeable battery

A battery charging means

Provisions for one or more lamps mounted on the equipment and shall be permitted to have terminals for remote lamps

A relaying device arranged to energize the lamps automatically upon failure of the supply to the unit equipment

The batteries shall be of suitable rating and capacity to supply and maintain the total lamp load associated with the unit for not less than the following:

For a period of 11/2 hours, without the voltage falling below 871/2 percent of normal voltage.

The unit equipment shall supply and maintain not less than 60 percent of the initial emergency illumination for a period of at least 11/2 hours.

Unit equipment shall be permanently fixed in place (i.e., not portable) and shall have all wiring to each unit installed in accordance with the requirements of any of the wiring methods in Chapter 3. Flexible cord-and-plug connection shall be permitted, provided that the cord does not exceed 900 mm (3 ft) in length. The branch circuit feeding the unit equipment shall be the same branch circuit as that serving the normal lighting in the area and connected ahead of any local switches. Legally required standby luminaires that obtain power from a unit equipment and are not part of the unit equipment shall be wired to the unit equipment by one of the wiring methods of Chapter 3.

Exception: In a separate and uninterrupted area supplied by a minimum of three normal lighting circuits, a separate branch circuit for unit equipment shall be permitted if it originates from the same panelboard as that of the normal lighting circuits and is provided with a lock-on feature.

Part IV Overcurrent Protection

701.30 Accessibility

The branch-circuit overcurrent devices in legally required standby circuits shall be accessible to authorized persons only.

701.31 Ground-Fault Protection of Equipment

The alternate source for legally required standby systems shall not be required to provide ground-fault protection of equipment with automatic disconnecting means. Ground-fault indication at the legally required standby source shall be provided in accordance with 701.6(D) if ground-fault protection of equipment with automatic disconnecting means is not provided.

701.32 Selective Coordination

Legally required standby system(s) overcurrent devices shall be selectively coordinated with all supply-side overcurrent protective devices.

Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.

Exception: Selective coordination shall not be required between two overcurrent devices located in series if no loads are connected in parallel with the downstream device.

Informational Note: See Informational Note Figure 701.32 for an example of how legally required standby system overcurrent protective devices (OCPDs) selectively coordinate with all supply-side OCPDs.

OCPD D selectively coordinates with OCPDs C, F, E, B, and A.

OCPD C selectively coordinates with OCPDs F, E, B, and A.

OCPD F selectively coordinates with OCPD E.

OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not a legally required standby system OCPD.

Informational Note Figure 701.32 Legally Required Standby System Selective Coordination.

Article 702 Optional Standby Systems

Part I General

702.1 Scope

This article applies to the installation and operation of optional standby systems.

The systems covered by this article consist of those that are permanently installed in their entirety, including prime movers, and those that are arranged for a connection to a premises wiring system from a portable alternate power supply.

702.2 Definition

The definition in this section shall apply within this article and throughout the Code.

Optional Standby Systems. Those systems intended to supply power to public or private facilities or property where life safety does not depend on the performance of the system. These systems are intended to supply on-site generated or stored power to selected loads either automatically or manually.

Informational Note: Optional standby systems are typically installed to provide an alternate source of electric power for such facilities as industrial and commercial buildings, farms, and residences and to serve loads such as heating and refrigeration systems, data processing and communications systems, and industrial processes that, when stopped during any power outage, could cause discomfort, serious interruption of the process, damage to the product or process, or the like.

702.4 Capacity and Rating

(A) Available Fault Current

Optional standby system equipment shall be suitable for the available fault current at its terminals.

(B) System Capacity

(1) Manual Transfer Equipment

Where manual transfer equipment is used, an optional standby system shall have adequate capacity and rating for the supply of all equipment intended to be operated at one time. The user of the optional standby system shall be permitted to select the load connected to the system.

(2) Automatic Transfer Equipment

Where automatic transfer equipment is used, an optional standby system shall comply with 702.4(B)(2)(a) or (B)(2)(b) in accordance with Article 220 or by another approved method.

(a) Full Load. The standby source shall be capable of supplying the full load that is transferred by the automatic transfer equipment.

(b) Load Management. Where a system is employed that will automatically manage the connected load, the standby source shall have a capacity sufficient to supply the maximum load that will be connected by the load management system.

702.5 Transfer Equipment

(A) General

Transfer equipment shall be required for all standby systems subject to the requirements of this article and for which an electric utility supply is either the normal or standby source. Transfer switches shall not be permitted to be reconditioned.

Exception: Temporary connection of a portable generator without transfer equipment shall be permitted where conditions of maintenance and supervision ensure that only qualified persons service the installation and where the normal supply is physically isolated by a lockable disconnecting means or by disconnection of the normal supply conductors.

(B) Meter-Mounted Transfer Switches

Transfer switches installed between the utility meter and the meter enclosure shall be listed meter-mounted transfer switches and shall be approved. Meter-mounted transfer switches shall be of the manual type unless rated as determined by 702.4(B)(2).

Informational Note: For more information, see UL 1008M, Transfer Switch Equipment, Meter Mounted.

(C) Documentation

In other than dwelling units, the short-circuit current rating of the transfer equipment, based on the specific overcurrent protective device type and settings protecting the transfer equipment, shall be field marked on the exterior of the transfer equipment.

(D) Inadvertent Interconnection

Transfer equipment shall be suitable for the intended use and shall be listed, designed, and installed so as to prevent the inadvertent interconnection of all sources of supply in any operation of the transfer equipment.

(E) Parallel Installation

Transfer equipment and electric power production systems installed to permit operation in parallel with the normal source shall also meet the requirements of Article 705.

702.6 Signals

Audible and visual signal devices shall be provided, where practicable, for the following purposes specified in 702.6(A) and (B).

(A) Malfunction

To indicate malfunction of the optional standby source.

(B) Carrying Load

To indicate that the optional standby source is carrying load.

Exception: Signals shall not be required for portable standby power sources.

702.7 Signs

(A) Standby

A sign shall be placed at the service-entrance equipment for commercial and industrial installations that indicates the type and location of each on-site optional standby power source. For one- and two-family dwelling units, a sign shall be placed at the disconnecting means required in 230.85 that indicates the location of each permanently installed on-site optional standby power source disconnect or means to shut down the prime mover as required in 445.18(D).

(B) Grounding

Where removal of a grounding or bonding connection in normal power source equipment interrupts the grounding electrode conductor connection to the alternate power source(s) grounded conductor, a warning sign shall be installed at the normal power source equipment stating:

WARNING:

SHOCK HAZARD EXISTS IF GROUNDING ELECTRODE CONDUCTOR OR BONDING JUMPER CONNECTION IN THIS EQUIPMENT IS REMOVED WHILE ALTERNATE SOURCE(S) IS ENERGIZED.

The warning sign(s) or label(s) shall comply with 110.21(B).

(C) Power Inlet

Where a power inlet is used for a temporary connection to a portable generator, a warning sign shall be placed near the inlet to indicate the type of derived system that the system is capable of based on the wiring of the transfer equipment. The sign shall display one of the following warnings:

WARNING:

FOR CONNECTION OF A SEPARATELY DERIVED (BONDED NEUTRAL) SYSTEM ONLY

or

WARNING:

FOR CONNECTION OF A NONSEPARATELY DERIVED (FLOATING NEUTRAL) SYSTEM ONLY

Part II Wiring

702.10 Wiring Optional Standby Systems

The optional standby system wiring shall be permitted to occupy the same raceways, cables, boxes, and cabinets with other general wiring.

702.11 Portable Generator Grounding

(A) Separately Derived System

Where a portable optional standby source is used as a separately derived system, it shall be grounded to a grounding electrode in accordance with 250.30.

(B) Nonseparately Derived System

Where a portable optional standby source is used as a nonseparately derived system, the equipment grounding conductor shall be bonded to the system grounding electrode.

702.12 Outdoor Generator Sets

(A) Portable Generators Greater Than 15 kW and Permanently Installed Generators

Where an outdoor housed generator set is equipped with a readily accessible disconnecting means in accordance with 445.18, and the disconnecting means is located within sight of the building or structure supplied, an additional disconnecting means shall not be required where ungrounded conductors serve or pass through the building or structure. Where the generator supply conductors terminate at a disconnecting means in or on a building or structure, the disconnecting means shall meet the requirements of 225.36.

(B) Portable Generators 15 kW or Less

Where a portable generator, rated 15 kW or less, is installed using a flanged inlet or other cord- and plug-type connection, a disconnecting means shall not be required where ungrounded conductors serve or pass through a building or structure.

(C) Power Inlets Rated at 100 Amperes or Greater, for Portable Generators

Equipment containing power inlets for the connection of a generator source shall be listed for the intended use. Systems with power inlets shall be equipped with an interlocked disconnecting means.

Exception No. 1: If the inlet device is rated as a disconnecting means.

Exception No. 2: Supervised industrial installations where permanent space is identified for the portable generator located within line of sight of the power inlets shall not be required to have interlocked disconnecting means nor inlets rated as disconnects.

Article 705 Interconnected Electric Power Production Sources

Part I General

705.1 Scope

This article covers installation of one or more electric power production sources operating in parallel with a primary source(s) of electricity.

Informational Note: Examples of the types of primary sources include a utility supply or an on-site electric power source(s).

705.2 Definitions

The definitions in this section shall apply within this article and throughout the Code.

Microgrid Interconnect Device (MID). A device that enables a microgrid system to separate from and reconnect to operate in parallel with a primary power source.

Informational Note: Microgrid controllers typically are used to measure and evaluate electrical parameters and provide the logic for the signal to initiate and complete transition processes. IEEE Std 2030.7-2017, IEEE Standard for the Specification of Microgrid Controllers, and IEEE Std 2030.8-2018, IEEE Standard for the Testing of Microgrid Controllers, provide information on microgrid controllers. IEEE Std 1547-2018, IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces, provides information on interconnection requirements.

Microgrid System. A premises wiring system that has generation, energy storage, and load(s), or any combination thereof, that includes the ability to disconnect from and parallel with the primary source.

Informational Note: The application of Article 705 to microgrid systems is limited by the exclusions in 90.2(B)(5) related to electric utilities. Additional information may be found in IEEE 1547, IEEE 2030.7, and IEEE 2030.8.

Power Source Output Circuit. The conductors between power production equipment and the service or distribution equipment.

705.6 Equipment Approval

All equipment shall be approved for the intended use. Interactive equipment intended to operate in parallel with electric power production sources including, but not limited to, interactive inverters, engine generators, energy storage equipment, and wind turbines shall be listed for interactive function or be evaluated for interactive function and have a field label applied, or both.

705.8 System Installation

Installation of one or more electrical power production sources operating in parallel with a primary source(s) of electricity shall be performed only by qualified persons.

Informational Note: See Article 100 for the definition of Qualified Person.

705.10 Identification of Power Sources

Diagram

A permanent plaque or directory shall be installed at each service equipment location, or at an approved readily visible location. The plaque or directory shall denote the location of each power source disconnecting means for the building or structure and be grouped with other plaques or directories for other on-site sources. The plaque or directory shall be marked with the wording "CAUTION: MULTIPLE SOURCES OF POWER." Any posted diagrams shall be correctly oriented with respect to the diagram's location. The marking shall comply with 110.21(B).

Exception: Installations with multiple co-located power production sources shall be permitted to be identified as a group(s). The plaque or directory shall not be required to identify each power source individually.

UpCodes Diagrams

P

Solar Labeling Requirements

705.11 Supply-Side Source Connections

An electric power production source, where connected on the supply side of the service disconnecting means as permitted in 230.82(6), shall comply with 705.11(A) through (E).

(A) Output Rating

The sum of the power source continuous current output ratings on a service, other than those controlled in accordance with 705.13, shall not exceed the ampacity of the service conductors.

Informational Note: See Article 100 definition for Service Conductors.

(B) Conductors

The power source output circuit conductors from the service conductors point of connection to the first overcurrent protection device shall be sized in accordance with 705.28 and in no case sized smaller than 6 AWG copper or 4 AWG aluminum. These conductors shall be installed in accordance with 230.30 or 230.43.

(C) Overcurrent Protection

The power source output circuit conductors shall be protected from overcurrent in accordance with 705.30. If fuses are not integral with the disconnecting means, the disconnecting means shall be located on the service side of the fuses. Where the power source output circuit conductors make their connection to the service outside of a building, they shall be protected by overcurrent devices in a readily accessible location outside the building or at the first readily accessible location where the power source conductors enter the building. Where the power source output circuit conductors make their connection to the service inside a building, they shall be protected with one of the following methods:

With an overcurrent device located within 3 m (10 ft) of conductor length in dwelling units and 5 m (16.5 ft) in other than dwelling units from the point of connection to the service

In other than a dwelling unit, with an overcurrent device located within 20 m (71 ft) of conductor length from the point of connection to the service, provided that cable limiters installed in all ungrounded conductors are located within 5 m (16.5 ft) of conductor length from the point of connection to the service

(D) Connections

The connection of power source output circuit conductors to the service conductors shall be made using listed connectors as described in 110.14 and comply with all enclosure fill requirements Any modifications to existing equipment shall be made in accordance with the manufacturer's instructions or the modification must be evaluated for the application and have a field label applied. For meter socket enclosures or other equipment under the exclusive control of the electric utility, only connections approved by the electric utility shall be permitted.

(E) Ground-Fault Protection

For connections rated 1000 amperes or more to solidly grounded wye services exceeding 150 volts to ground but not exceeding 1000 volts, phase-to-phase, ground-fault protection meeting the requirements of 230.95 shall be provided.

705.12 Load-Side Source Connections

The output of an interconnected electric power source shall be permitted to be connected to the load side of the service disconnecting means of the other source(s) at any distribution equipment on the premises. Where distribution equipment or feeders are fed simultaneously by a primary source of electricity and one or more other power source and are capable of supplying multiple branch circuits or feeders, or both, the interconnecting equipment shall comply with 705.12(A) through (E). Where a power control system (PCS) is installed in accordance with 705.13, the setting of the PCS controller shall be considered the power-source output circuit current in 705.12(A) through (E).

(A) Dedicated Overcurrent and Disconnect

Each source interconnection of one or more power sources installed in one system shall be made at a dedicated circuit breaker or fusible disconnecting means.

(B) Bus or Conductor Ampere Rating

The power source output circuit current multiplied by 125 percent shall be used in ampacity calculations for 705.12(B)(1) through (B)(3).

(1) Feeders

Where the power source output connection is made to a feeder, the feeder shall have an ampacity greater than or equal to 125 percent of the power-source output circuit current. Where the power-source output connection is made to a feeder at a location other than the opposite end of the feeder from the primary source overcurrent device, that portion of the feeder on the load side of the power source output connection shall be protected by one of the following:

The feeder ampacity shall be not less than the sum of the primary source overcurrent device and 125 percent of the power-source output circuit current.

An overcurrent device at the load side of the power source connection point shall be rated not greater than the ampacity of the feeder.

(2) Taps

Where power source output connections are made at feeders, all taps shall be sized based on the sum of 125 percent of all power source(s) output circuit current(s) and the rating of the overcurrent device protecting the feeder conductors for sizing tap conductors using the calculations in 240.21(B).

(3) Busbars

Diagram

One of the following methods shall be used to determine the ratings of busbars:

The sum of 125 percent of the power source(s) output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed the ampacity of the busbar.

Informational Note: This general rule assumes no limitation in the number of the loads or sources applied to busbars or their locations.

Where two sources, one a primary power source and the other another power source, are located at opposite ends of a busbar that contains loads, the sum of 125 percent of the power-source(s) output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed 120 percent of the ampacity of the busbar. The busbar shall be sized for the loads connected in accordance with Article 220. A permanent warning label shall be applied to the distribution equipment adjacent to the back-fed breaker from the power source that displays the following or equivalent wording:

WARNING:

POWER SOURCE OUTPUT CONNECTION — DO NOT RELOCATE THIS OVERCURRENT DEVICE.

The warning sign(s) or label(s) shall comply with 110.21(B).

The sum of the ampere ratings of all overcurrent devices on panelboards, both load and supply devices, excluding the rating of the overcurrent device protecting the busbar, shall not exceed the ampacity of the busbar. The rating of the overcurrent device protecting the busbar shall not exceed the rating of the busbar. Permanent warning labels shall be applied to distribution equipment displaying the following or equivalent wording:

WARNING:

THIS EQUIPMENT FED BY MULTIPLE SOURCES. TOTAL RATING OF ALL OVERCURRENT DEVICES EXCLUDING MAIN SUPPLY OVERCURRENT DEVICE SHALL NOT EXCEED AMPACITY OF BUSBAR.

The warning sign(s) or label(s) shall comply with 110.21(B).

A connection at either end of a center-fed panelboard in dwellings shall be permitted where the sum of 125 percent of the power-source(s) output circuit current and the rating of the overcurrent device protecting the busbar does not exceed 120 percent of the current rating of the busbar.

Connections shall be permitted on switchgear, switchboards, and panelboards in configurations other than those permitted in 705.12(B)(3)(1) through (B)(3)(4) where designed under engineering supervision that includes available fault-current and busbar load calculations.

Connections shall be permitted on busbars of panelboards that supply lugs connected to feed-through conductors. The feed-through conductors shall be sized in accordance with 705.12(B)(1). Where an overcurrent device is installed at the supply end of the feed-through conductors, the busbar in the supplying panelboard shall be permitted to be sized in accordance with 705.12(B)(3)(1) through 705.12(B)(3)(3).

Upcodes Diagrams

(C) Marking

Equipment containing overcurrent devices in circuits supplying power to a busbar or conductor supplied from multiple sources shall be marked to indicate the presence of all sources.

(D) Suitable for Backfeed

Fused disconnects, unless otherwise marked, shall be considered suitable for backfeed. Circuit breakers not marked "line" and "load" shall be considered suitable for backfeed. Circuit breakers marked "line" and "load" shall be considered suitable for backfeed or reverse current if specifically rated.

(E) Fastening

Listed plug-in-type circuit breakers back-fed from electric power sources that are listed and identified as interactive shall be permitted to omit the additional fastener normally required by 408.36(D) for such applications.

705.13 Power Control Systems

A power control system (PCS) shall be listed and evaluated to control the output of one or more power production sources, energy storage systems (ESS), and other equipment. The PCS shall limit current and loading on the busbars and conductors supplied by the PCS.

For the circuits connected to a PCS, the PCS shall limit the current to the ampacity of the conductors or the ratings of the busbars to which it is connected in accordance with 705.13(A) through (E).

(A) Monitoring

The PCS controller shall monitor all currents within the PCS. Any busbar or conductor on the load side of the service disconnecting means that is not monitored by the PCS shall comply with 705.12. Where the PCS is connected in accordance with 705.11, the PCS shall monitor the service conductors and prevent overload of these conductors.

(B) Settings

The sum of all PCS-controlled currents plus all monitored currents from other sources of supply shall not exceed the ampacity of any busbar or conductor supplied by the power production sources. Where the PCS is connected to an overcurrent device protecting any busbar or conductor not monitored by the PCS, the setting of the PCS controller shall be set within the ratings of that overcurrent device.

(C) Overcurrent Protection

The PCS shall provide overcurrent protection either by overcurrent devices or by the PCS including the functionality as an overcurrent device in the product listing.

Informational Note: Some PCS are listed to provide overcurrent protection.

(D) Single Power Source Rating

The rating of the overcurrent device for any single power source controlled by the PCS shall not exceed the rating of the busbar or the ampacity of the conductors to which it is connected.

(E) Access to Settings

The access to settings of the PCS shall be restricted to qualified personnel in accordance with the requirements of 240.6(C).

705.14 Output Characteristics

The output of a power production source operating in parallel with an electrical supply system shall be compatible with the voltage, wave shape, and frequency of the system to which it is connected. Synchronous generators operating in parallel with an electrical supply system shall be provided with the necessary equipment to establish and maintain a synchronous condition.

Informational Note: The term compatible does not necessarily mean matching the primary source wave shape.

705.16 Interrupting and Short-Circuit Current Rating

Consideration shall be given to the contribution of fault currents from all interconnected power sources for the interrupting and short-circuit current ratings of equipment on interactive systems.

705.20 Disconnecting Means, Source

Diagram

Means shall be provided to disconnect power source output circuit conductors of electric power production equipment from conductors of other systems.

The disconnecting means shall comply with the following:

Be one of the following types:

A manually operable switch or circuit breaker

A load-break-rated pull-out switch

A power-operated or remote-controlled switch or circuit breaker that is manually operable locally and opens automatically when control power is interrupted

A device listed or approved for the intended application

Simultaneously disconnect all ungrounded conductors of the circuit

Located where readily accessible

Externally operable without exposed live parts

Enclosures with doors or hinged covers with exposed live parts when open that require a tool to open or are lockable where readily accessible to unqualified persons

Plainly indicate whether in the open (off) or closed (on) position

Have ratings sufficient for the maximum circuit current, available fault current, and voltage that is available at the terminals

Be marked in accordance with the warning in 690.13(B), where the line and load terminals are capable of being energized in the open position

Informational Note: With interconnected power sources, some equipment, including switches and fuses, is likely to be energized from both directions. See 240.40.

Upcodes Diagrams

705.25 Wiring Methods

(A) General

All raceway and cable wiring methods included in Chapter 3 of this Code and other wiring systems and fittings specifically listed, intended, and identified for use with power production systems and equipment shall be permitted. Where wiring devices with integral enclosures are used, sufficient length of cable shall be provided to facilitate replacement.

(B) Flexible Cords and Cables

Flexible cords and cables, where used to connect the moving parts of a power production system or where used for ready removal for maintenance and repair, shall comply with Article 400 and shall be listed and identified as DG Cable, Distributed Generation Cable, hard service cord, or portable power cable, shall be suitable for extra-hard usage, shall be listed for outdoor use, and shall be water resistant. Cables exposed to sunlight shall be sunlight resistant. Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, or connectors in accordance with 110.14(A).

(C) Multiconductor Cable Assemblies

Multiconductor cable assemblies used in accordance with their listings shall be permitted.

Informational Note: See UL 3003, Distributed Generation Cables, for additional information on DG Cable, Distributed Generation Cable. An ac module harness is one example of a multiconductor cable assembly.

705.28 Circuit Sizing and Current

(A) Calculation of Maximum Circuit Current

Where not elsewhere required or permitted in this Code, the maximum current for the circuit shall be the continuous output current rating of the power production equipment.

(B) Conductor Ampacity

Where not elsewhere required or permitted in this Code, the circuit conductors shall be sized to carry not less than the largest of the following:

The maximum currents in 705.28(A) multiplied by 125 percent without adjustment or correction factors

The maximum currents in 705.28(A) with adjustment and correction factors

Where connected to feeders, if smaller than the feeder conductors, the ampacity as calculated in 240.21(B) based on the over-current device protecting the feeder

(C) Neutral Conductors

Neutral conductors shall be permitted to be sized in accordance with either 705.28(C)(1) or (C)(2).

(1) Single-Phase Line-to-Neutral Power Sources

Where not elsewhere required or permitted in this Code, the ampacity of a neutral conductor to which a single-phase line-to-neutral power source is connected shall not be smaller than the ampacity in 705.28(B).

(2) Neutral Conductor Used Solely for Instrumentation, Voltage, Detection, or Phase Detection

A power production equipment neutral conductor used solely for instrumentation, voltage detection, or phase detection shall be permitted to be sized in accordance with 250.102.

705.30 Overcurrent Protection

(A) Circuit and Equipment

Power source output circuit conductors and equipment shall be provided with overcurrent protection. Circuits connected to more than one electrical source shall have overcurrent devices located to provide overcurrent protection from all sources.

(B) Overcurrent Device Ratings

The overcurrent devices in other than generator systems shall be sized to carry not less than 125 percent of the maximum currents as calculated in 705.28(A). The rating or setting of overcurrent devices shall be permitted in accordance with 240.4(B) and (C).

Exception: Circuits containing an assembly together with its overcurrent device(s) that is listed for continuous operation at 100 percent of its rating shall be permitted to be utilized at 100 percent of its rating.

(C) Power Transformers

Transformers with sources on each side shall be provided with overcurrent protection in accordance with 450.3. The primary shall be the side connected to the largest source of available fault current. Secondary protection shall not be required for a transformer secondary that has a current rating not less than the sum of the rated continuous output currents of the power sources connected to that secondary.

(D) Generators

Generators shall be provided with overcurrent protection in accordance with 445.12.

705.32 Ground-Fault Protection

Where protection is installed in accordance with 230.95, the output of an interactive system shall be connected to the supply side of the ground-fault protection.

Exception: Connection shall be permitted to be made to the load side of ground-fault protection, if there is ground-fault protection for equipment from all ground-fault current sources.

705.40 Loss of Primary Source

The output of electric power production equipment shall be automatically disconnected from all ungrounded conductors of the interconnected systems when one or more of the phases to which it is connected opens. The electric power production equipment shall not be reconnected until all the phases of the interconnected system to which it is connected are restored. This requirement shall not be applicable to electric power production equipment providing power to an emergency or legally required standby system.

Exception: A listed interactive inverter shall trip or shall be permitted to automatically cease exporting power when one or more of the phases of the interconnected system opens and shall not be required to automatically disconnect all ungrounded conductors from the primary source. A listed interactive inverter shall be permitted to automatically or manually resume exporting power to the interconnected system once all phases of the source to which it is connected are restored.

Informational Note No. 1: Risks to personnel and equipment associated with the primary source could occur if an interactive electric power production source can operate as an intentional island. Special detection methods are required to determine that a primary source supply system outage has occurred and whether there should be automatic disconnection. When the primary source supply system is restored, special detection methods are typically required to limit exposure of power production sources to out-of-phase reconnection.

Informational Note No. 2: Induction-generating equipment connected on systems with significant capacitance can become self-excited upon loss of the primary source and experience severe overvoltage as a result.

Interactive power production equipment shall be permitted to operate in island mode to supply loads that have been disconnected from the electric power production and distribution network.

705.45 Unbalanced Interconnections

(A) Single Phase

Single-phase power sources in interactive systems shall be connected to 3-phase power systems in order to limit unbalanced voltages at the point of interconnection to not more than 3 percent.

Informational Note: For interactive power sources, unbalanced voltages can be minimized by the same methods that are used for single-phase loads on a 3-phase power system. See ANSI/C84.1-2016, Electric Power Systems and Equipment — Voltage Ratings (60 Hertz).

(B) Three Phase

Three-phase power sources in interactive systems shall have all phases automatically de-energized upon loss of, or unbalanced, voltage in one or more phases unless the interconnected system is designed so that significant unbalanced voltages will not result.

Part II Microgrid Systems

705.50 System Operation

Microgrid systems shall be permitted to disconnect from the primary source of power or other interconnected electric power production sources and operate as an isolated microgrid system operating in island mode.

705.60 Primary Power Source Connection

Connections to primary power sources that are external to the microgrid system shall comply with the requirements of 705.11, 705.12, or 705.13. Power source conductors connecting to a microgrid system, including conductors supplying distribution equipment, shall be considered as power source output conductors.

705.65 Reconnection to Primary Power Source

Microgrid systems that reconnect to primary power sources shall be provided with the necessary equipment to establish a synchronous transition.

705.70 Microgrid Interconnect Devices (MID)

Microgrid interconnect devices shall comply with the following:

Be required for any connection between a microgrid system and a primary power source

Be evaluated for the application and have a field label applied or be listed for the application

Have sufficient number of overcurrent devices located to provide overcurrent protection from all sources

Informational Note: MID functionality is often incorporated in an interactive or multimode inverter, energy storage system, or similar device identified for interactive operation.

Article 706 Energy Storage Systems

Part I General

706.1 Scope

This article applies to all energy storage systems (ESS) having a capacity greater than 3.6 MJ (1 kWh) that may be stand-alone or interactive with other electric power production sources. These systems are primarily intended to store and provide energy during normal operating conditions.

Informational Note No. 1: For batteries rated in ampere hours, kWh is equal to the nominal rated voltage times ampere-hour rating divided by 1000.

Informational Note No. 2: There can be a subtle distinction between a battery storing energy and an energy storage system. A battery storing energy is not necessarily an ESS. See Article 480. An ESS can be comprised of batteries storing energy. See Article 706.

Informational Note No. 3: The following standards are frequently referenced for the installation of energy storage systems:

NFPA 111-2016, Standard on Stored Electrical Energy Emergency and Standby Systems

NECA 416-2016, Recommended Practice for Installing Energy Storage Systems (ESS)

UL 810A, Electrochemical Capacitors

UL 1973, Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail (LER) Applications

UL 1989, Standard for Standby Batteries

UL 9540, Standard for Safety Energy Storage Systems and Equipment

UL Subject 2436, Spill Containment For Stationary Lead Acid Battery Systems

706.2 Definitions

The definitions in this section shall apply only within this article.

Diversion Charge Controller. Equipment that regulates the charging process of an ESS by diverting power from energy storage to direct-current or alternating-current loads or to an interconnected utility service.

Energy Storage System (ESS). One or more components assembled together capable of storing energy and providing electrical energy into the premises wiring system or an electric power production and distribution network.

Informational Note No. 1: ESS(s) can include but is not limited to batteries, capacitors, and kinetic energy devices (e.g., flywheels and compressed air). Energy storage systems can include inverters or converters to change voltage levels or to make a change between an ac or a dc system.

Informational Note No. 2: These systems differ from other storage systems such as a UPS system, which is a power supply used to provide alternating current power to a load for some period of time in the event of a power failure.

Flow Battery. An energy storage component similar to a fuel cell that stores its active materials in the form of two electrolytes external to the reactor interface. When in use, the electrolytes are transferred between reactor and storage tanks.

Informational Note: Two commercially available flow battery technologies are zinc bromine and vanadium redox, sometimes referred to as pumped electrolyte ESS.

Inverter Utilization Output Circuit. Conductors between the multimode or stand-alone inverter and utilization equipment.

706.3 Qualified Personnel

The installation and maintenance of ESS equipment and all associated wiring and interconnections shall be performed only by qualified persons.

Informational Note: See Article 100 for the definition of qualified person.

706.4 System Requirements

Each ESS shall be provided with a nameplate plainly visible after installation and marked with the following:

Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for supplying the ESS can be identified

Rated frequency

Number of phases, if ac

Rating (kW or kVA)

Available fault current derived by the ESS at the output terminals

Maximum output and input current of the ESS at the output terminals

Maximum output and input voltage of the ESS at the output terminals

Utility-interactive capability, if applicable

706.5 Listing

Energy storage systems shall be listed.

706.6 Multiple Systems

Multiple ESSs shall be permitted to be installed in or on a single building or structure.

706.7 Maintenance

Energy storage systems shall be maintained in proper and safe operating condition. The required maintenance shall be in accordance with the manufacturer's requirements and industry standards. A written record of the system maintenance shall be kept and shall include records of repairs and replacements necessary to maintain the system in proper and safe operating condition.

Informational Note: For information related to general electrical equipment maintenance and developing an effective electrical preventive maintenance (EPM) program, see NFPA 70B-2019, Recommended Practice for Electrical Equipment Maintenance, or ANSI/NETA ATS-2017, Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.

706.8 Storage Batteries

Storage batteries not associated with an ESS shall comply with Article 480.

706.9 Maximum Voltage

The maximum voltage of an ESS shall be the rated ESS input and output voltage(s) indicated on the ESS nameplate(s) or system listing.

Part II Disconnecting Means

706.15 Disconnecting Means

(A) ESS Disconnecting Means

A disconnecting means shall be provided for all ungrounded conductors derived from an ESS and shall be permitted to be integral to listed ESS equipment. The disconnecting means shall comply with all of the following:

The disconnecting means shall be readily accessible.

The disconnecting means shall be located within sight of the ESS. Where it is impractical to install the disconnecting means within sight of the ESS, the disconnect shall be installed as close as practicable, and the location of the disconnecting means shall be field marked on or immediately adjacent to the ESS. The marking shall be of sufficient durability to withstand the environment involved and shall not be handwritten.

The disconnecting means shall be lockable open in accordance with 110.25.

For one-family and two-family dwellings, a disconnecting means or its remote control shall be located at a readily accessible location outside the building.

(B) Remote Actuation

Where controls to activate the disconnecting means of an ESS are used and are not located within sight of the system, the location of the controls shall be field marked on the disconnecting means.

(C) Notification and Marking

Each ESS disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position and be permanently marked "ENERGY STORAGE SYSTEM DISCONNECT." The disconnecting means shall be legibly marked in the field to indicate the following:

Nominal ESS ac voltage and maximum ESS dc voltage

Available fault current derived from the ESS

An arc-flash label applied in accordance with acceptable industry practice

Date the calculation was performed

Exception: List items (2), (3), and (4) shall not apply to one- and two-family dwellings.

Informational Note No. 1: Industry practices for equipment labeling are described in NFPA 70E-2018, Standard for Electrical Safety in the Workplace. This standard provides specific criteria for developing arc-flash labels for equipment that provides nominal system voltage, incident energy levels, arc-flash boundaries, minimum required levels of personal protective equipment, and so forth.

Informational Note No. 2: Battery equipment suppliers can provide information about available fault current on any particular battery model.

For ESS disconnecting means where the line and load terminals may be energized in the open position, the device shall be marked with the following words or equivalent:

WARNING

ELECTRIC SHOCK HAZARD

TERMINALS ON THE LINE AND LOAD

SIDES MAY BE ENERGIZED IN THE OPEN POSITION

The notification(s) and marking(s) shall comply with 110.21(B).

(D) Partitions Between Components

Where circuits from the input or output terminals of energy storage components in an ESS pass through a wall, floor, or ceiling, a readily accessible disconnecting means shall be provided within sight of the energy storage component. Fused disconnecting means or circuit breakers shall be permitted to be used.

706.16 Connection to Energy Sources

The connection of an ESS to sources of energy shall comply with 706.16(A) through (F).

(A) Source Disconnect

A disconnect that has multiple sources of power shall disconnect all energy sources when in the off position.

(B) Identified Interactive Equipment

ESS that operate in parallel with other ac sources shall use inverters that are listed and identified as interactive.

(C) Loss of Interactive System Power

Upon loss of a primary source of power, an ESS with a utility-interactive inverter shall comply with the requirements of 705.40.

(D) Unbalanced Interconnections

Unbalanced ac connections between an ESS and other ac electric power production sources shall be in accordance with 705.45.

(E) Other Energy Sources

The connection of an ESS to other energy sources shall be in accordance with 705.12 and Parts III and VI of Article 712.

(F) Stand-Alone Operation

Where the output of an ESS is capable of operating in stand-alone mode, the requirements of 710.15 shall apply.

Part III Installation Requirements

706.20 General

(A) Ventilation

Provisions appropriate to the energy storage technology shall be made for sufficient diffusion and ventilation of any possible gases from the storage device, if present, to prevent the accumulation of an explosive mixture. Ventilation of an ESS shall be permitted to be provided in accordance with the manufacturer's recommendations and listing for the system.

Informational Note No. 1: See NFPA 1-2018, Fire Code, Chapter 52, for ventilation considerations for specific battery chemistries.

Informational Note No. 2: Some storage technologies do not require ventilation.

Informational Note No. 3: A source for design of ventilation of battery systems is IEEE 1635-2018/ASHRAE Guideline 21-2018, Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications.

Informational Note No. 4: Fire protection considerations are addressed in NFPA 1-2018, Fire Code.

(B) Dwelling Units

An ESS for one- and two-family dwelling units shall not exceed 100 volts dc between conductors or to ground.

Exception: Where live parts are not accessible during routine ESS maintenance, a maximum ESS voltage of 600 volts dc shall be permitted.

(C) Spaces About ESS Components

(1) General

Working spaces for ESS shall comply with 110.26 and 110.34.

(2) Space Between Components

ESSs shall be permitted to have space between components in accordance with the manufacturer's instructions and listing.

Informational Note: Additional space may be needed to accommodate ESS hoisting equipment, tray removal, or spill containment.

706.21 Directory (Identification of Power Sources)

ESS shall be indicated by markings or labels that shall be in accordance with 110.21(B).

(A) Facilities With Utility Services and ESS

Plaques or directories shall be installed in accordance with 705.10 and 712.10.

(B) Facilities With Stand-Alone Systems

Plaques or directories shall be installed in accordance with 710.10.

Part IV Circuit Requirements

706.30 Circuit Sizing and Current

(A) Maximum Rated Current for a Specific Circuit

The maximum current for the specific circuit shall be calculated in accordance with 706.30(A)(1) through (A)(5).

(1) Nameplate-Rated Circuit Current

Circuit current shall be the rated current indicated on the ESS nameplate(s) or system listing. Where the ESS has separate input (charge) and output (discharge) circuits or ratings, these shall be considered individually. Where the same terminals on the ESS are used for charging and discharging, the rated current shall be the greater of the two.

(2) Inverter Output Circuit Current

The maximum current shall be the inverter continuous output current rating.

(3) Inverter Input Circuit Current

The maximum current shall be the continuous inverter input current rating when the inverter is producing rated power at the lowest input voltage.

(4) Inverter Utilization Output Circuit Current

The maximum current shall be the continuous ac output current rating of the inverter when the inverter is producing rated power.

(5) DC to DC Converter Output Current

The maximum current shall be the dc-to-dc converter continuous output current rating.

(B) Conductor Ampacity

The ampacity of the feeder circuit conductors from the ESS(s) to the wiring system serving the loads to be serviced by the system shall not be less than the greater of the (1) nameplate(s)-rated circuit current as determined in accordance with 706.30(A)(1) or (2) the rating of the ESS(s) overcurrent protective device(s).

(C) Ampacity of Grounded or Neutral Conductor

If the output of a single-phase, 2-wire ESS output(s) is connected to the grounded or neutral conductor and a single ungrounded conductor of a 3-wire system or of a 3-phase, 4-wire, wye-connected system, the maximum unbalanced neutral load current plus the ESS(s) output rating shall not exceed the ampacity of the grounded or neutral conductor.

706.31 Overcurrent Protection

(A) Circuits and Equipment

ESS circuit conductors shall be protected in accordance with the requirements of Article 240. Protection devices for ESS circuits shall be in accordance with the requirements of 706.31(B) through (F). Circuits shall be protected at the source from overcurrent.

(B) Overcurrent Device Ampere Ratings

Overcurrent protective devices, where required, shall be rated in accordance with Article 240 and the rating provided on systems serving the ESS and shall be not less than 125 percent of the maximum currents calculated in 706.30(A).

Exception: Where the assembly, including the overcurrent protective devices, is listed for operation at 100 percent of its rating, the ampere rating of the overcurrent devices shall be permitted to be not less than the maximum currents calculated in 706.30(B).

(C) Direct Current Rating

Overcurrent protective devices, either fuses or circuit breakers, used in any dc portion of an ESS shall be listed for dc and shall have the appropriate voltage, current, and interrupting ratings for the application.

(D) Current Limiting

A listed and labeled current-limiting overcurrent protective device shall be installed adjacent to the ESS for each dc output circuit.

Exception: Where current-limiting overcurrent protection is provided for the dc output circuits of a listed ESS, additional current-limiting overcurrent devices shall not be required.

(E) Fuses

Means shall be provided to disconnect any fuses associated with ESS equipment and components when the fuse is energized from both directions and is accessible to other than qualified persons. Switches, pullouts, or similar devices that are rated for the application shall be permitted to serve as a means to disconnect fuses from all sources of supply.

(F) Location

Where circuits from the input or output terminals of energy storage components in an ESS pass through a wall, floor, or ceiling, overcurrent protection shall be provided at the energy storage component end of the circuit.

706.33 Charge Control

(A) General

Provisions shall be provided to control the charging process of the ESS. All adjustable means for control of the charging process shall be accessible only to qualified persons.

(B) Diversion Charge Controller

(1) Sole Means of Regulating Charging

An ESS employing a diversion charge controller as the sole means of regulating charging shall be equipped with a second independent means to prevent overcharging of the storage device.

(2) Circuits With Diversion Charge Controller and Diversion Load

Circuits containing a diversion charge controller and a diversion load shall comply with the following:

The current rating of the diversion load shall be less than or equal to the current rating of the diversion load charge controller. The voltage rating of the diversion load shall be greater than the maximum ESS voltage. The power rating of the diversion load shall be at least 150 percent of the power rating of the charging source.

The conductor ampacity and the rating of the overcurrent device for this circuit shall be at least 150 percent of the maximum current rating of the diversion charge controller.

(3) ESS Using Interactive Inverters

Systems using interactive inverters to control energy storage state-of-charge by diverting excess power into an alternate electric power production and distribution system, such as utility, shall comply with 706.33(B)(3)(a) and (B)(3)(b).

(a) These systems shall not be required to comply with 706.33(B)(2).

(b) These systems shall have a second, independent means of controlling the ESS charging process for use when the alternate system is not available or when the primary charge controller fails or is disabled.

(C) Charge Controllers and DC-to-DC Converters

Where charge controllers and other DC-to-DC power converters that increase or decrease the output current or output voltage with respect to the input current or input voltage are installed, all of the following shall apply:

The ampacity of the conductors in output circuits shall be based on the maximum rated continuous output current of the charge controller or converter for the selected output voltage range.

The voltage rating of the output circuits shall be based on the maximum voltage output of the charge controller or converter for the selected output voltage range.

Part V Flow Battery Energy Storage Systems

Part V applies to ESSs composed of or containing flow batteries.

Informational Note: Due to the unique design features and difference in operating characteristics of flow batteries as compared with that of storage batteries such as lead acid or lithium ion batteries, the requirements for flow batteries have been included here rather than in Article 480.

706.40 General

All electrical connections to and from the system and system components shall be in accordance with the applicable provisions of Article 692. The system and system components shall also meet Parts I, II, and III of this article. Unless otherwise directed by this article, flow battery ESS shall comply with the applicable provisions of Article 692.

706.41 Electrolyte Classification

The electrolyte(s) that are acceptable for use in the batteries associated with the ESS shall be identified by name and chemical composition. Such identification shall be provided by readily discernable signage adjacent to every location in the system where the electrolyte can be put into or taken out of the system.

706.42 Electrolyte Containment

Flow battery systems shall be provided with a means for electrolyte containment to prevent spills of electrolyte from the system. An alarm system shall be provided to signal an electrolyte leak from the system. Electrical wiring and connections shall be located and routed in a manner that mitigates the potential for exposure to electrolytes.

706.43 Flow Controls

Controls shall be provided to safely shut down the system in the event of electrolyte blockage.

706.44 Pumps and Other Fluid Handling Equipment

Pumps and other fluid handling equipment are to be rated/specified suitable for exposure to the electrolytes.

Part VI Other Energy Storage Technologies

Part VI applies to ESSs using other technologies intended to store energy and when there is a demand for electrical power to use the stored energy to generate the needed power.

706.50 General

All electrical connections to and from the system and system components shall be in accordance with the applicable provisions of this Code. Unless otherwise directed by this article, other energy storage technologies shall comply with the applicable provisions of Part III of Article 705.

Article 708 Critical Operations Power Systems (COPS)

Part I General

708.1 Scope

This article applies to the installation, operation, monitoring, control, and maintenance of the portions of the premises wiring system intended to supply, distribute, and control electricity to designated critical operations areas (DCOA) in the event of disruption to elements of the normal system.

Critical operations power systems are those systems so classed by municipal, state, federal, or other codes by any governmental agency having jurisdiction or by facility engineering documentation establishing the necessity for such a system. These systems include but are not limited to power systems, HVAC, fire alarm, security, communications, and signaling for designated critical operations areas.

Informational Note No. 1: Critical operations power systems are generally installed in vital infrastructure facilities that, if destroyed or incapacitated, would disrupt national security, the economy, public health or safety; and where enhanced electrical infrastructure for continuity of operation has been deemed necessary by governmental authority.

Informational Note No. 2: For further information on disaster and emergency management, see NFPA 1600-2019, Standard on Continuity, Emergency, and Crisis Management.

Informational Note No. 3: For further information regarding performance of emergency and standby power systems, see NFPA 110-2019, Standard for Emergency and Standby Power Systems.

Informational Note No. 4: For specification of locations where emergency lighting is considered essential to life safety, see NFPA 101-2018, Life Safety Code, or the applicable building code.

Informational Note No. 5: For further information regarding physical security, see NFPA 730-2018, Guide for Premises Security.

Informational Note No. 6: Threats to facilities that may require transfer of operation to the critical systems include both naturally occurring hazards and human-caused events. See also A.5.3.2 of NFPA 1600-2019, Standard on Continuity, Emergency, and Crisis Management.

Informational Note No. 7: See Informative Annex F, Availability and Reliability for Critical Operations Power Systems; and Development and Implementation of Functional Performance Tests (FPTs) for Critical Operations Power Systems.

Informational Note No. 8: See Informative Annex G, Supervisory Control and Data Acquisition (SCADA).

Informational Note No. 9: Text that is followed by a reference in brackets has been extracted from NFPA 1600-2019, Standard on Continuity, Emergency, and Crisis Management. Only editorial changes were made to the extracted text to make it consistent with this Code.

708.2 Definitions

The definitions in this section shall apply within this article and throughout the Code.

Commissioning. The acceptance testing, integrated system testing, operational tune-up, and start-up testing is the process by which baseline test results verify the proper operation and sequence of operation of electrical equipment, in addition to developing baseline criteria by which future trend analysis can identify equipment deterioration.

Critical Operations Power Systems (COPS). Power systems for facilities or parts of facilities that require continuous operation for the reasons of public safety, emergency management, national security, or business continuity.

Designated Critical Operations Areas (DCOA). Areas within a facility or site designated as requiring critical operations power.

Supervisory Control and Data Acquisition (SCADA). An electronic system that provides monitoring and controls for the operation of the critical operations power system. This can include the fire alarm system, security system, control of the HVAC, the start/stop/monitoring of the power supplies and electrical distribution system, annunciation and communications equipment to emergency personnel, facility occupants, and remote operators.

708.4 Risk Assessment

Risk assessment for critical operations power systems shall be documented and shall be conducted in accordance with 708.4(A) through (C).

Informational Note: Chapter 5 of NFPA 1600-2019, Standard on Continuity, Emergency, and Crisis Management, provides additional guidance concerning risk assessment and hazard analysis.

(A) Conducting Risk Assessment

In critical operations power systems, risk assessment shall be performed to identify hazards, the likelihood of their occurrence, and the vulnerability of the electrical system to those hazards.

(B) Identification of Hazards

Hazards to be considered at a minimum shall include, but shall not be limited to, the following:

Naturally occurring hazards (geological, meteorological, and biological)

Human-caused events (accidental and intentional) [1600:5.3.2]

(C) Developing Mitigation Strategy

Based on the results of the risk assessment, a strategy shall be developed and implemented to mitigate the hazards that have not been sufficiently mitigated by the prescriptive requirements of this Code.

708.5 Physical Security

Physical security shall be provided for critical operations power systems in accordance with 708.5(A) and (B).

(A) Risk Assessment

Based on the results of the risk assessment, a strategy for providing physical security for critical operations power systems shall be developed, documented, and implemented.

(B) Restricted Access

Electrical circuits and equipment for critical operations power systems shall be accessible to qualified personnel only.

708.6 Testing and Maintenance

(A) Conduct or Witness Test

The authority having jurisdiction shall conduct or witness a test of the complete system upon installation and periodically afterward.

(B) Tested Periodically

Systems shall be tested periodically on a schedule approved by the authority having jurisdiction to ensure the systems are maintained in proper operating condition.

(C) Maintenance

The authority having jurisdiction shall require a documented preventive maintenance program for critical operations power systems.

Informational Note: For information concerning maintenance, see NFPA 70B-2019, Recommended Practice for Electrical Equipment Maintenance.

(D) Written Record

A written record shall be kept of such tests and maintenance.

(E) Testing Under Load

Means for testing all critical power systems during maximum anticipated load conditions shall be provided.

Informational Note: For information concerning testing and maintenance of emergency power supply systems (EPSSs) that are also applicable to COPS, see NFPA 110-2019, Standard for Emergency and Standby Power Systems.

708.8 Commissioning

(A) Commissioning Plan

A commissioning plan shall be developed and documented.

Informational Note: For further information on developing a commissioning program see NFPA 70B-2019, Recommended Practice for Electrical Equipment Maintenance.

(B) Component and System Tests

The installation of the equipment shall undergo component and system tests to ensure that, when energized, the system will function properly.

(C) Baseline Test Results

A set of baseline test results shall be documented for comparison with future periodic maintenance testing to identify equipment deterioration.

(D) Functional Performance Tests

A functional performance test program shall be established, documented, and executed upon complete installation of the critical system in order to establish a baseline reference for future performance requirements.

Informational Note: See Informative Annex F for more information on developing and implementing a functional performance test program.

Part II Circuit Wiring and Equipment

708.10 Feeder and Branch Circuit Wiring

(A) Identification

(1) Boxes and Enclosures

In a building or at a structure where a critical operations power system and any other type of power system are present, all boxes and enclosures (including transfer switches, generators, and power panels) for critical operations power system circuits shall be permanently marked so they will be readily identified as a component of the critical operations power system.

(2) Receptacle Identification

In a building in which COPS are present with other types of power systems described in other sections in this article, the cover plates for the receptacles or the receptacles themselves supplied from the COPS shall have a distinctive color or marking so as to be readily identifiable. Nonlocking-type, 125-volt, 15- and 20-ampere receptacles supplied from the COPS shall have an illuminated face or an indicator light to indicate that there is power to the receptacle.

Exception: If the COPS supplies power to a DCOA that is a stand-alone building, receptacle cover plates or the receptacles themselves shall not be required to have distinctive marking.

(B) Wiring

Wiring of two or more COPS circuits supplied from the same source shall be permitted in the same raceway, cable, box, or cabinet. Wiring from a COPS source or COPS source distribution overcurrent protection to critical loads shall be kept entirely independent of all other wiring and equipment.

Exception: Where the COPS feeder is installed in transfer equipment enclosures.

(C) COPS Feeder Wiring Requirements

COPS feeders shall comply with 708.10(C)(1) through (C)(3).

(1) Protection Against Physical Damage

The wiring of the COPS system shall be protected against physical damage. Only the following wiring methods shall be permitted:

Rigid metal conduit, intermediate metal conduit, or Type MI cable.

Where encased in not less than 50 mm (2 in.) of concrete, any of the following wiring methods shall be permitted:

Schedule 40 or Schedule 80 rigid polyvinyl chloride conduit (Type PVC)

Reinforced thermosetting resin conduit (Type RTRC)

Electrical metallic tubing (Type EMT)

Flexible nonmetallic or jacketed metallic raceways

Jacketed metallic cable assemblies listed for installation in concrete

Where provisions must be made for flexibility at equipment connection, one or more of the following shall also be permitted:

Flexible metal fittings

Flexible metal conduit with listed fittings

Liquidtight flexible metal conduit with listed fittings

(2) Fire Protection for Feeders

Feeders shall meet one of the following conditions:

The cable or raceway is protected by a listed electrical circuit protective system with a minimum 2-hour fire rating.

Informational Note: The listing organization provides information for electrical circuit protection systems on proper installation requirements to maintain the fire rating.

The cable or raceway is a listed fire-resistive cable system with a minimum 2-hour fire rating.

Informational Note No. 1: Fire-resistive cables are tested to ANSI/UL 2196-2017, Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control and Data Cables.

Informational Note No. 2: The listing organization provides information for fire-resistive cable systems on proper installation requirements to maintain the fire rating.

The cable or raceway is protected by a listed fire-rated assembly that has a minimum fire rating of 2 hours.

The cable or raceway is encased in a minimum of 50 mm (2 in.) of concrete.

(3) Floodplain Protection

Where COPS feeders are installed below the level of the 100-year floodplain, the insulated circuit conductors shall be listed for use in a wet location and be installed in a wiring method that is permitted for use in wet locations.

(D) COPS Branch Circuit Wiring

Outside the DCOA. COPS branch circuits installed outside the DCOA shall comply with the physical and fire protection requirements of 708.10(C)(1) through (C)(3).

Within the DCOA. Any of the wiring methods recognized in Chapter 3 of this Code shall be permitted within the DCOA.

708.11 Branch Circuit and Feeder Distribution Equipment

(A) Branch Circuit Distribution Equipment

COPS branch circuit distribution equipment shall be located within the same DCOA as the branch circuits it supplies.

(B) Feeder Distribution Equipment

Equipment for COPS feeder circuits (including transfer equipment, transformers, and panelboards) shall comply with (1) and (2):

Be located in spaces with a 2-hour fire resistance rating

Be located above the 100-year floodplain

708.12 Feeders and Branch Circuits Supplied by COPS

Feeders and branch circuits supplied by the COPS shall supply only equipment specified as required for critical operations use.

708.14 Wiring of HVAC, Fire Alarm, Security, Emergency Communications, and Signaling Systems

All conductors or cables shall be installed using any of the metal wiring methods permitted by 708.10(C)(1) and, in addition, shall comply with the following, as applicable:

All cables for fire alarm, security, signaling systems, and emergency communications shall be shielded twisted pair cables or installed to comply with the performance requirements of the system.

Shields of cables for fire alarm, security, signaling systems, and emergency communications shall be arranged in accordance with the manufacturer's published installation instructions.

Optical fiber cables shall be used for connections between two or more buildings on the property and under single management.

A listed primary protector shall be provided on all communications circuits. Listed secondary protectors shall be provided at the terminals of the communications circuits.

Conductors for all control circuits rated above 50 volts shall be rated not less than 600 volts.

Communications, fire alarm, and signaling circuits shall use relays with contact ratings that exceed circuit voltage and current ratings in the controlled circuit.

All cables for fire alarm, security, and signaling systems shall be riser-rated and shall be a listed 2-hour electrical circuit protective system. Emergency communications cables shall be Type CMR-CI or shall be riser-rated and shall be a listed 2-hour electrical circuit protective system.

Control, monitoring, and power wiring to HVAC systems shall be a listed 2-hour electrical circuit protective system.

Part III Power Sources and Connection

708.20 Sources of Power

(A) General Requirements

Current supply shall be such that, in the event of failure of the normal supply to the DCOA, critical operations power shall be available within the time required for the application. The supply system for critical operations power, in addition to the normal services to the building and meeting the general requirements of this section, shall be one or more of the types of systems described in 708.20(E) through (H).

Informational Note No. 1: Assignment of degree of reliability of the recognized critical operations power system depends on the careful evaluation in accordance with the risk assessment.

Informational Note No. 2: For guidance about determining degree of reliability, see IEEE 3006.5—2014 Recommended Practice for the Use of Probability Methods for Conducting a Reliability Analysis of Industrial and Commercial Power Systems.

(B) Fire Protection

Where located within a building, equipment for sources of power as described in 708.20(E) through (H) shall be installed either in spaces fully protected by an approved automatic fire protection system or in spaces with a 2-hour fire rating.

(C) Grounding

All sources of power shall be grounded as a separately derived source in accordance with 250.30.

Exception: Where the equipment containing the main bonding jumper or system bonding jumper for the normal source and the feeder wiring to the transfer equipment are installed in accordance with 708.10(C) and 708.11(B).

(D) Surge Protection Devices

Surge protection devices shall be provided at all facility distribution voltage levels.

(E) Storage Battery

An automatic battery charging means shall be provided. Batteries shall be compatible with the charger for that particular installation. Automotive-type batteries shall not be used.

(F) Generator Set

(1) Prime Mover-Driven

Generator sets driven by a prime mover shall be provided with means for automatically starting the prime mover on failure of the normal service. A time-delay feature permitting a minimum 15-minute setting shall be provided to avoid retransfer in case of short-time reestablishment of the normal source.

(2) Power for Fuel Transfer Pumps

Where power is needed for the operation of the fuel transfer pumps to deliver fuel to a generator set day tank, this pump shall be connected to the COPS.

(3) Dual Supplies

Prime movers shall not be solely dependent on a public utility gas system for their fuel supply or municipal water supply for their cooling systems. Means shall be provided for automatically transferring from one fuel supply to another where dual fuel supplies are used.

(4) Battery Power and Dampers

Where a storage battery is used for control or signal power or as the means of starting the prime mover, it shall be suitable for the purpose and shall be equipped with an automatic charging means independent of the generator set. Where the battery charger is required for the operation of the generator set, it shall be connected to the COPS. Where power is required for the operation of dampers used to ventilate the generator set, the dampers shall be connected to the COPS.

(5) Outdoor Generator Sets

(a) Permanently Installed Generators and Portable Generators Greater Than 15 kW. Where an outdoor housed generator set is equipped with a readily accessible disconnecting means in accordance with 445.18, and the disconnecting means is located within sight of the building or structure supplied, an additional disconnecting means shall not be required where ungrounded conductors serve or pass through the building or structure. Where the generator supply conductors terminate at a disconnecting means in or on a building or structure, the disconnecting means shall meet the requirements of 225.36.

(b) Portable Generators 15 kW or Less. Where a portable generator, rated 15 kW or less, is installed using a flanged inlet or other cord-and plug-type connection, a disconnecting means shall not be required where ungrounded conductors serve or pass through a building or structure.

(6) Means for Connecting Portable or Vehicle-Mounted Generator

Where the COPS is supplied by a single generator, a means to connect a portable or vehicle-mounted generator shall be provided.

(7) On-Site Fuel Supply

Where internal combustion engines are used as the prime mover, an on-site fuel supply shall be provided. The on-site fuel supply shall be secured and protected in accordance with the risk assessment.

(G) Uninterruptible Power Supplies

Uninterruptible power supplies used as the sole source of power for COPS shall comply with 708.20(E) and (F).

(H) Fuel Cell System

Installation of a fuel cell system shall meet the requirements of Parts II through VIII of Article 692.

708.21 Ventilation

Adequate ventilation shall be provided for the alternate power source for continued operation under maximum anticipated ambient temperatures.

Informational Note: NFPA 110-2019, Standard for Emergency and Standby Power Systems, and NFPA 111-2019, Standard on Stored Energy Emergency and Standby Power Systems, include additional information on ventilation air for combustion and cooling.

708.22 Capacity of Power Sources

(A) Capacity and Rating

A COPS shall have capacity and rating for all loads to be operated simultaneously for continuous operation with variable load for an unlimited number of hours, except for required maintenance of the power source. A portable, temporary, or redundant alternate power source shall be available for use whenever the COPS power source is out of service for maintenance or repair.

(B) Selective Load Pickup, Load Shedding, and Peak Load Shaving

The alternate power source shall be permitted to supply COPS emergency, legally required standby, and optional loads where the source has adequate capacity or where automatic selective load pickup and load shedding is provided as needed to ensure adequate power to (1) the COPS and emergency circuits, (2) the legally required standby circuits, and (3) the optional standby circuits, in that order of priority. The alternate power source shall be permitted to be used for peak load shaving, provided these conditions are met.

Peak load-shaving operation shall be permitted for satisfying the test requirement of 708.6(B), provided all other conditions of 708.6 are met.

(C) Duration of COPS Operation

The alternate power source shall be capable of operating the COPS for a minimum of 72 hours at full load of DCOA with a steady-state voltage within ±10 percent of nominal utilization voltage.

708.24 Transfer Equipment

(A) General

Transfer equipment, including automatic transfer switches, shall be automatic and identified for emergency use. Transfer equipment shall be designed and installed to prevent the inadvertent interconnection of normal and critical operations sources of supply in any operation of the transfer equipment. Transfer equipment and electric power production systems installed to permit operation in parallel with the normal source shall meet the requirements of Article 705.

Transfer equipment shall not be permitted to be reconditioned.

(B) Bypass Isolation Switches

Means shall be permitted to bypass and isolate the transfer equipment. Where bypass isolation switches are used, inadvertent parallel operation shall be avoided.

(C) Automatic Transfer Switches

Where used with sources that are not inherently synchronized, automatic transfer switches shall comply with 708.24(C)(1) and (C)(2).

Automatic transfer switches shall be listed for emergency use.

Automatic transfer switches shall be electrically operated and mechanically held.

(D) Bypass Isolation Automatic Transfer Switches

Where loads are supplied by only one automatic transfer switch, the automatic transfer switch shall include a bypass isolation switch to facilitate maintenance as required in 708.6(C) without jeopardizing continuity of power. When the bypass isolation transfer switch is in the bypass mode, either it shall automatically initiate transfer between power sources upon loss of the connected power source or it shall remain actively supervised by a qualified person who can manually initiate a transfer between power sources.

(E) Use

Transfer equipment shall supply only COPS loads.

(F) Documentation

The short-circuit current rating of the transfer equipment, based on the specific overcurrent protective device type and settings protecting the transfer equipment, shall be field marked on the exterior of the transfer equipment.

708.30 Branch Circuits Supplied by COPS

Branch circuits supplied by the COPS shall only supply equipment specified as required for critical operations use.

Part IV Overcurrent Protection

708.50 Accessibility

The feeder- and branch-circuit overcurrent devices shall be accessible to authorized persons only.

708.52 Ground-Fault Protection of Equipment

(A) Applicability

The requirements of 708.52 shall apply to critical operations (including multiple occupancy buildings) with critical operation areas.

(B) Feeders

Where ground-fault protection is provided for operation of the service disconnecting means or feeder disconnecting means as specified by 230.95 or 215.10, an additional step of ground-fault protection shall be provided in all next level feeder disconnecting means downstream toward the load. Such protection shall consist of overcurrent devices and current transformers or other equivalent protective equipment that causes the feeder disconnecting means to open.

(C) Testing

When equipment ground-fault protection is first installed, each level shall be tested to ensure that ground-fault protection is operational.

Informational Note: Testing is intended to verify the ground-fault function is operational. The performance test is not intended to verify selectivity in 708.52(D), as this is often coordinated similarly to circuit breakers by reviewing time and current curves and properly setting the equipment. (Selectivity of fuses and circuit breakers is not performance tested for overload and short circuit.)

(D) Selectivity

Ground-fault protection for operation of the service and feeder disconnecting means shall be fully selective such that the feeder device, but not the service device, shall open on ground faults on the load side of the feeder device. Separation of ground-fault protection time-current characteristics shall conform to the manufacturer's recommendations and shall consider all required tolerances and disconnect operating time to achieve 100 percent selectivity.

Informational Note: See 230.95, Informational Note No. 4, for transfer of alternate source where ground-fault protection is applied.

708.54 Selective Coordination

Critical operations power system(s) overcurrent devices shall be selectively coordinated with all supply-side overcurrent protective devices.

Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.

Exception: Selective coordination shall not be required between two overcurrent devices located in series if no loads are connected in parallel with the downstream device.

Informational Note: See Informational Note Figure 708.54 for an example of how critical operations power system overcurrent protective devices (OCPDs) selectively coordinate with all supply-side OCPDs.

OCPD D selectively coordinates with OCPDs C, F, E, B, and A.

OCPD C selectively coordinates with OCPDs F, E, B, and A.

OCPD F selectively coordinates with OCPD E.

OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not a critical operations power system OCPD.

Informational Note Figure 708.54 Critical Operations Power System Selective Coordination.

Part V System Performance and Analysis

708.64 Emergency Operations Plan

A facility with a COPS shall have documented an emergency operations plan. The plan shall consider emergency operations and response, recovery, and continuity of operations.

Informational Note: NFPA 1600-2019, Standard on Continuity, Emergency, and Crisis Management, Section 5.7, provides guidance for the development and implementation of emergency plans.

Article 710 Stand-Alone Systems

710.1 Scope

This article covers electric power production systems that operate in island mode and installations not connected to an electric power production and distribution network.

Informational Note: These systems are capable of operating in island mode, independent from an electric power production and distribution network, and include isolated microgrid systems or interactive with other power sources. Stand-alone systems often include a single or a compatible interconnection of sources such as engine generators, solar PV, wind, ESS, or batteries.

710.6 Equipment Approval

All equipment shall be approved for the intended use in accordance with one of the following:

Be listed for the application

Be evaluated for the application and have a field label applied

Informational Note: Inverters identified as "multimode" and "stand-alone" are specifically identified and certified to operate in this application. Stand-alone inverters operate in island mode. Multimode inverters operate in either island mode (previously called "stand-alone mode") or interactive mode, if it has been installed with the optional utility grid connection. A multimode inverter will only operate in island mode if it is never connected to an electric utility supply. Stand-alone inverters are not evaluated for and are not intended for connection to export power in parallel with an electric utility.

710.10 Identification of Power Sources

A permanent plaque or directory shall be installed at a building supplied by a standalone system at each service equipment location, or at an approved readily visible location. The plaque or directory shall denote the location of each power source disconnecting means for the building or be grouped with other plaques or directories for other on-site sources. Where multiple sources supply the building, the plaque or directory shall be marked with the wording "CAUTION: MULTIPLE SOURCES OF POWER." The marking shall comply with 110.21(B).

Exception: Installations with multiple co-located power production sources shall be permitted to be identified as a group(s). The plaque or directory shall not be required to identify each power source individually.

710.12 Stand-Alone Inverter Input Circuit Current

The maximum current shall be the stand-alone continuous inverter input current rating when the inverter is producing rated power at the lowest input voltage.

710.15 General

Premises wiring systems shall be adequate to meet the requirements of this Code for similar installations supplied by a feeder or service. The wiring on the supply side of the building or structure disconnecting means shall comply with the requirements of this Code, except as modified by 710.15(A) through (G).

(A) Supply Output

Power supply to premises wiring systems fed by stand-alone or isolated microgrid power sources shall be permitted to have less capacity than the calculated load. The capacity of the sum of all sources of the stand-alone supply shall be equal to or greater than the load posed by the largest single utilization equipment connected to the system. Calculated general lighting loads shall not be considered as a single load.

Informational Note: For general-use loads the system capacity can be calculated using the sum of the capacity of the firm sources, such as generators and ESS inverters. For specialty loads intended to be powered directly from a variable source, the capacity can be calculated using the sum of the variable sources, such as PV or wind inverters, or the combined capacity of both firm and variable sources.

(B) Sizing and Protection

The circuit conductors between a stand-alone source and a building or structure disconnecting means shall be sized based on the sum of the output ratings of the stand-alone source(s). For three-phase interconnections, the phase loads shall be controlled or balanced to be compatible with specifications of the sum of the power supply capacities.

(C) Single 120-Volt Supply

Stand-alone and isolated microgrid systems shall be permitted to supply 120 volts to single-phase, 3-wire, 120/240-volt service equipment or distribution panels where there are no 240-volt outlets and where there are no multiwire branch circuits. In all installations, the sum of the ratings of the power sources shall be less than the rating of the neutral bus in the service equipment. This equipment shall be marked with the following words or equivalent:

WARNING:

SINGLE 120-VOLT SUPPLY. DO NOT CONNECT MULTIWIRE BRANCH CIRCUITS!

The warning sign(s) or label(s) shall comply with 110.21(B).

(D) Three-Phase Supply

Stand-alone and microgrid systems shall be permitted to supply three-phase, 3-wire or 4-wire systems.

(E) Energy Storage or Backup Power System Requirements

Energy storage or backup power supplies shall not be required.

(F) Back-Fed Circuit Breakers

Plug-in-type back-fed circuit breakers connected to an interconnected supply shall be secured in accordance with 408.36(D). Circuit breakers marked "line" and "load" shall not be backfed.

(G) Voltage and Frequency Control

The stand-alone or isolated microgrid supply shall be controlled so that voltage and frequency remain within suitable limits for the connected loads.

Article 712 Direct Current Microgrids

Part I General

712.1 Scope

This article applies to direct current microgrids.

712.2 Definitions

The definitions in this section shall apply only within this article.

Direct Current Microgrid (DC Microgrid). A direct current microgrid is a power distribution system consisting of more than one interconnected dc power source, supplying dc-dc converter(s), dc load(s), and/or ac load(s) powered by dc-ac inverter(s). A dc microgrid is typically not directly connected to an ac primary source of electricity, but some dc microgrids interconnect via one or more dc-ac bidirectional converters or dc-ac inverters.

Informational Note: Direct current power sources include ac-dc converters (rectifiers), bidirectional dc-ac inverters/converters, photovoltaic systems, wind generators, energy storage systems (including batteries), and fuel cells.

Grounded, Functionally. A system that has an electrical ground reference for operational purposes that is not solidly grounded.

Informational Note: Examples of operational reasons for functionally grounded systems include ground-fault detection and performance-related issues for some power sources.

Grounded Three-Wire DC System. A system with a solid connection or reference-ground between the center point of a bipolar dc power source and the equipment grounding system.

Grounded Two-Wire DC System A system that has a solid connection or reference-ground between one of the currentcarrying conductors and the equipment grounding system.

Nominal Voltage. A value assigned to a circuit or system for the purpose of conveniently designating its dc voltage class.

Informational Note: The actual voltage at which a circuit operates can vary from the nominal voltage within a range that permits satisfactory operation of equipment.

Primary DC Source. A source that supplies the majority of the dc load in a dc microgrid.

Reference-Grounded DC System. A system that is not solidly grounded but has a low-resistance electrical reference that maintains voltage to ground in normal operation.

Ungrounded DC System. A system that has no direct or resistive connection between the current-carrying conductors and the equipment grounding system.

712.3 Other Articles

Wherever the requirements of other articles of this Code and Article 712 differ, the requirements of Article 712 shall apply. DC microgrids interconnected through an inverter or bi-directional converter with ac electric power production sources shall comply with Article 705.

712.4 Listing and Labeling

Any equipment used in the dc circuits of a dc microgrid shall be listed and labeled for dc use.

712.10 Directory

(A) Source Directory

A permanent directory denoting all dc electric power sources operating to supply the dc microgrid shall be installed at each source location capable of acting as the primary dc source.

(B) Building Directory

A building supplied by a dc microgrid system shall have a permanent plaque or directory installed outside the building at each service equipment location or at an approved readily visible location. The plaque or directory shall denote the location of each power source disconnecting means on or in the building or be grouped with other plaques or directories for other on-site sources.

Exception: Multiple power production sources that are grouped at one location shall be permitted to be identified as a group.

Part II Circuit Requirements

712.25 Identification of Circuit Conductors

Ungrounded circuit conductors in dc microgrids shall be identified according to the requirements of 210.5(C)(2) for branch circuits and 215.12(C)(2) for feeders.

712.30 System Voltage

The system voltage of a dc microgrid shall be determined by one of the following methods:

The nominal voltage to ground for solidly grounded systems

The nominal voltage to ground for reference-grounded systems

The highest nominal voltage between conductors for resistively grounded dc systems and ungrounded dc systems.

Informational Note: Examples of nominal dc system voltages include but are not limited to 24, 48, 125, 190/380, or 380 volts.

Part III Disconnecting Means

712.34 DC Source Disconnecting Means

The output of each dc source shall have a readily accessible disconnecting means that is lockable open in accordance with 110.25 and adjacent to the source.

712.35 Disconnection of Ungrounded Conductors

In solidly grounded two- and three-wire systems, the disconnecting means shall simultaneously open all ungrounded conductors. In ungrounded, resistively grounded and reference-grounded systems, such devices shall open all current-carrying conductors.

712.37 Directional Current Devices

Disconnecting means shall be listed, shall be marked for use in a single current direction, and shall only be used in the designated current direction.

Informational Note: Examples of directional current devices are magnetically quenched contactors and semiconductor switches in overcurrent devices.

Part IV Wiring Methods

712.52 System Grounding

(A) General

Direct-current microgrids shall be grounded in accordance with 250.162.

(B) Over 300 Volts

DC microgrids operating at voltages greater than 300 volts dc shall be reference-grounded dc systems or functionally grounded dc systems.

712.55 Ground Fault Detection Equipment

Ungrounded, reference grounded, or functionally grounded dc microgrids operating at greater than 60 volts dc shall have ground fault detection that indicates that a fault has occurred. The ground fault equipment shall be marked in accordance with 250.167(C).

712.57 Arc Fault Protection

Where required elsewhere in this Code, specific systems within the dc microgrid shall have arc fault protection. The arc fault protection equipment shall be listed.

Informational Note: Section 90.4 applies when suitable equipment for arc fault protection is not available.

Part V Marking

712.62 Distribution Equipment and Conductors

Distribution equipment and conductors shall be marked as required elsewhere in this Code.

712.65 Available DC Fault Current

(A) Field Marking

The available dc fault current on the dc microgrid shall be field marked at the dc source(s). The field marking(s) shall include the date the available fault current calculation was performed and be of sufficient durability to withstand the environment involved.

(B) Modifications

When modifications to the electrical installation occur that affect the available fault current at the dc source, the available fault current shall be verified or recalculated as necessary to ensure the equipment ratings are sufficient for the available fault current at the line terminals of the equipment. The required field marking(s) in 712.65(A) shall indicate the new available fault current and date.

Part VI Protection

712.70 Overcurrent Protection

Equipment and conductors connected to more than one electrical source shall have overcurrent protective devices to provide protection from all sources.

712.72 Interrupting and Short-Circuit Current Ratings

Consideration shall be given to the contribution of available fault currents from all interconnected power sources for the interrupting ratings and short-circuit current ratings of equipment in the dc microgrid system(s). Overcurrent protective devices and equipment used within a dc microgrid shall have an interrupting rating at nominal circuit voltage or a short-circuit current rating sufficient for the available fault current at the line terminals of the equipment.

Part VII Systems Over 1000 Volts

712.80 General

Systems with a maximum voltage between conductors of over 1000 volts dc shall comply with Article 490 and other requirements in this Code applicable to installations rated over 1000 volts.

Article 720 Circuits and Equipment Operating at Less Than 50 Volts

720.1 Scope

This article covers installations operating at less than 50 volts, direct current or alternating current.

720.2 Other Articles

Direct current or alternating-current installations operating at less than 50 volts, as covered in 411.1 through 411.8; Part VI of Article 517; Part II of Article 551; Parts II and III and 552.60(B) of Article 552; 650.1 through 650.9; 669.1 through 669.9; Parts I and VIII of Article 690; Parts I, II and III of Article 725; or Parts I, II, and III of Article 760, shall not be required to comply with this article.

720.3 Hazardous (Classified) Locations

Installations within the scope of this article and installed in hazardous (classified) locations shall also comply with the appropriate provisions for hazardous (classified) locations in other applicable articles of this Code.

720.4 Conductors

Conductors shall not be smaller than 12 AWG copper or equivalent. Conductors for appliance branch circuits supplying more than one appliance or appliance receptacle shall not be smaller than 10 AWG copper or equivalent.

720.5 Lampholders

Standard lampholders that have a rating of not less than 660 watts shall be used.

720.6 Receptacle Rating

Receptacles shall have a rating of not less than 15 amperes.

720.7 Receptacles Required

Receptacles of not less than 20-ampere rating shall be provided in kitchens, laundries, and other locations where portable appliances are likely to be used.

720.9 Batteries

Installations of storage batteries shall comply with 480.1 through 480.6 and 480.9 through 480.11.

720.11 Mechanical Execution of Work

Circuits operating at less than 50 volts shall be installed in a neat and workmanlike manner. Cables shall be supported by the building structure in such a manner that the cable will not be damaged by normal building use.

Article 725 Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits

Part I General

725.1 Scope

This article covers remote-control, signaling, and power-limited circuits that are not an integral part of a device or of utilization equipment.

Informational Note: The circuits described herein are characterized by usage and electrical power limitations that differentiate them from electric light and power circuits; therefore, alternative requirements to those of Chapters 1 through 4 are given with regard to minimum wire sizes, ampacity adjustment and correction factors, overcurrent protection, insulation requirements, and wiring methods and materials.

725.2 Definitions

The definitions in this section shall apply only within this article.

Abandoned Class 2, Class 3, and PLTC Cable. Installed Class 2, Class 3, and PLTC cable that is not terminated at equipment and not identified for future use with a tag.

Cable Bundle. A group of cables that are tied together or in contact with one another in a closely packed configuration for at least 1.0 m (40 in.).

Informational Note: Random or loose installation of individual cables can result in less heating. Combing of the cables can result in less heat dissipation and more signal cross talk between cables.

725.3 Other Articles

In addition to the requirements of this article, circuits and equipment shall comply with the articles or sections listed in 725.3(A) through (P). Only those sections of Article 300 referenced in this article shall apply to Class 1, Class 2, and Class 3 circuits.

(A) Number and Size of Conductors in Raceway

Section 300.17.

(B) Spread of Fire or Products of Combustion

Installation of Class 1, Class 2, and Class 3 circuits shall comply with 300.21.

(C) Ducts, Plenums, and Other Air-Handling Spaces

Class 1, Class 2, and Class 3 circuits installed in ducts, plenums, or other space used for environmental air shall comply with 300.22.

Exception No. 1: Class 2 and Class 3 cables selected in accordance with Table 725.154 and installed in accordance with 725.135(B) and 300.22(B), Exception shall be permitted to be installed in ducts specifically fabricated for environmental air.

Exception No. 2: Class 2 and Class 3 cables selected in accordance with Table 725.154 and installed in accordance with 725.135(C) shall be permitted to be installed in other spaces used for environmental air (plenums).

(D) Hazardous (Classified) Locations

Class 1, Class 2, and Class 3 circuits installed in hazardous (classified) locations shall comply with 501.10(B)(1), 501.150, 502.10(B)(1), 502.150, 503.10(A)(1), 503.150, 506.15(A), 506.15(C), 511.7(B)(1), 515.7(A), and Article 517, Part IV.

(E) Cable Trays

Parts I and II of Article 392, where installed in cable tray.

(F) Motor Control Circuits

Article 430, Part VI, where tapped from the load side of the motor branch-circuit protective device(s) as specified in 430.72(A).

(G) Instrumentation Tray Cable

See 727.1 and 727.4 through 727.9.

(H) Raceways Exposed to Different Temperatures

Installations shall comply with 300.7(A).

(I) Vertical Support for Fire-Rated Cables and Conductors

Vertical installations of circuit integrity (CI) cables and conductors installed in a raceway or conductors and cables of electrical circuit protective systems shall be installed in accordance with 300.19.

(J) Bushing

A bushing shall be installed where cables emerge from raceway used for mechanical support or protection in accordance with 300.15(C).

(K) Installation of Conductors With Other Systems

Installations shall comply with 300.8.

(L) Corrosive, Damp, or Wet Locations

Class 2 and Class 3 cables installed in corrosive, damp, or wet locations shall comply with the applicable requirements in 110.11, 300.5(B), 300.6, 300.9, and 310.10(F).

(M) Cable Routing Assemblies

Class 2, Class 3, and Type PLTC cables shall be permitted to be installed in plenum cable routing assemblies, riser cable routing assemblies, and generalpurpose cable routing assemblies selected in accordance with Table 800.154(c), listed in accordance with 800.182, and installed in accordance with 800.110(C) and 800.113.

(N) Communications Raceways

Class 2, Class 3, and Type PLTC cables shall be permitted to be installed in plenum communications raceways, riser communications raceways, and general-purpose communications raceways selected in accordance with Table 800.154(b), listed in accordance with 800.182, and installed in accordance with 800.113 and 362.24 through 362.56, where the requirements applicable to electrical nonmetallic tubing (ENT) apply.

(O) Temperature Limitation of Class 2 and Class 3 Cables

The requirements of 310.14(A)(3) on the temperature limitation of conductors shall apply to Class 2 and Class 3 cables.

(P) Identification of Equipment Grounding Conductors

Equipment grounding conductors shall be identified in accordance with 250.119.

Exception: Conductors with green insulation shall be permitted to be used as ungrounded signal conductors for Types CL3P, CL2P, CL3R, CL2R, CL3, CL2, CL3X, CL2X, and substitute cables installed in accordance with 725.154(A).

725.21 Access to Electrical Equipment Behind Panels Designed to Allow Access

Access to electrical equipment shall not be denied by an accumulation of wires and cables that prevents removal of panels, including suspended ceiling panels.

725.24 Mechanical Execution of Work

Class 1, Class 2, and Class 3 circuits shall be installed in a neat and workmanlike manner. Cables and conductors installed exposed on the surface of ceilings and sidewalls shall be supported by the building structure in such a manner that the cable will not be damaged by normal building use. Such cables shall be supported by straps, staples, hangers, cable ties, or similar fittings designed and installed so as not to damage the cable. The installation shall also comply with 300.4(D).

Informational Note: Paint, plaster, cleaners, abrasives, corrosive residues, or other contaminants can result in an undetermined alteration of Class 1, Class 2, Class 3, and PLTC cable properties.

725.25 Abandoned Cables

The accessible portion of abandoned Class 2, Class 3, and PLTC cables shall be removed. Where cables are identified for future use with a tag, the tag shall be of sufficient durability to withstand the environment involved.

725.30 Class 1, Class 2, and Class 3 Circuit Identification

Class 1, Class 2, and Class 3 circuits shall be identified at terminal and junction locations in a manner that prevents unintentional interference with other circuits during testing and servicing.

725.31 Safety-Control Equipment

(A) Remote-Control Circuits

Remote-control circuits for safety-control equipment shall be classified as Class 1 if the failure of the equipment to operate introduces a direct fire or life hazard. Room thermostats, water temperature regulating devices, and similar controls used in conjunction with electrically controlled household heating and air conditioning shall not be considered safety-control equipment.

(B) Physical Protection

Where damage to remote-control circuits of safety-control equipment would introduce a hazard, as covered in 725.31(A), all conductors of such remote-control circuits shall be installed in rigid metal conduit, intermediate metal conduit, rigid nonmetallic conduit, electrical metallic tubing, Type MI cable, or Type MC cable, or be otherwise suitably protected from physical damage.

725.35 Class 1, Class 2, and Class 3 Circuit Requirements

A remote-control, signaling, or power-limited circuit shall comply with the following parts of this article:

Class 1 Circuits: Parts I and II

Class 2 and Class 3 Circuits: Parts I and III

Part II Class 1 Circuits

725.41 Class 1 Circuit Classifications and Power Source Requirements

Class 1 circuits shall be classified as either Class 1 power-limited circuits where they comply with the power limitations of 725.41(A) or as Class 1 remote-control and signaling circuits where they are used for remote-control or signaling purposes and comply with the power limitations of 725.41(B).

(A) Class 1 Power-Limited Circuits

These circuits shall be supplied from a source that has a rated output of not more than 30 volts and 1000 volt-amperes.

(1) Class 1 Transformers

Transformers used to supply power-limited Class 1 circuits shall comply with the applicable sections within Parts I and II of Article 450.

(2) Other Class 1 Power Sources

Power sources other than transformers shall be protected by overcurrent devices rated at not more than 167 percent of the volt-ampere rating of the source divided by the rated voltage. The overcurrent devices shall not be interchangeable with overcurrent devices of higher ratings. The overcurrent device shall be permitted to be an integral part of the power supply.

To comply with the 1000 volt-ampere limitation of 725.41(A), the maximum output (VAmax) of power sources other than transformers shall be limited to 2500 volt-amperes, and the product of the maximum current (Imax) and maximum voltage (Vmax) shall not exceed 10,000 volt-amperes. These ratings shall be determined with any overcurrent-protective device bypassed.

VAmax is the maximum volt-ampere output after one minute of operation regardless of load and with overcurrent protection bypassed, if used. Current-limiting impedance shall not be bypassed when determining VAmax.

Imax is the maximum output current under any noncapacitive load, including short circuit, and with overcurrent protection bypassed, if used. Current-limiting impedance should not be bypassed when determining Imax. Where a current-limiting impedance, listed for the purpose or as part of a listed product, is used in combination with a stored energy source, for example, storage battery, to limit the output current, Imax limits apply after 5 seconds.

Vmax is the maximum output voltage regardless of load with rated input applied.

(B) Class 1 Remote-Control and Signaling Circuits

These circuits shall not exceed 600 volts. The power output of the source shall not be required to be limited.

725.43 Class 1 Circuit Overcurrent Protection

Overcurrent protection for conductors 14 AWG and larger shall be provided in accordance with the conductor ampacity, without applying the ampacity adjustment and correction factors of 310.14 to the ampacity calculation. Overcurrent protection shall not exceed 7 amperes for 18 AWG conductors and 10 amperes for 16 AWG.

Exception: Where other articles of this Code permit or require other overcurrent protection.

Informational Note: For example, see 430.72 for motors, 610.53 for cranes and hoists, and 517.74(B) and 660.9 for X-ray equipment.

725.45 Class 1 Circuit Overcurrent Device Location

Overcurrent devices shall be located as specified in 725.45(A), (B), (C), (D), or (E).

(A) Point of Supply

Overcurrent devices shall be located at the point where the conductor to be protected receives its supply.

(B) Feeder Taps

Class 1 circuit conductors shall be permitted to be tapped, without overcurrent protection at the tap, where the overcurrent device protecting the circuit conductor is sized to protect the tap conductor.

(C) Branch-Circuit Taps

Class 1 circuit conductors 14 AWG and larger that are tapped from the load side of the overcurrent protective device(s) of a controlled light and power circuit shall require only short-circuit and ground-fault protection and shall be permitted to be protected by the branch-circuit overcurrent protective device(s) where the rating of the protective device(s) is not more than 300 percent of the ampacity of the Class 1 circuit conductor.

(D) Primary Side of Transformer

Class 1 circuit conductors supplied by the secondary of a single-phase transformer having only a 2-wire (single-voltage) secondary shall be permitted to be protected by overcurrent protection provided on the primary side of the transformer, provided this protection is in accordance with 450.3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio. Transformer secondary conductors other than 2-wire shall not be considered to be protected by the primary overcurrent protection.

(E) Input Side of Electronic Power Source

Class 1 circuit conductors supplied by the output of a single-phase, listed electronic power source, other than a transformer, having only a 2-wire (single-voltage) output for connection to Class 1 circuits shall be permitted to be protected by overcurrent protection provided on the input side of the electronic power source, provided this protection does not exceed the value determined by multiplying the Class 1 circuit conductor ampacity by the output-to-input voltage ratio. Electronic power source outputs, other than 2-wire (single voltage), shall not be considered to be protected by the primary overcurrent protection.

725.46 Class 1 Circuit Wiring Methods

Class 1 circuits shall be installed in accordance with Part I of Article 300 and with the wiring methods from the appropriate articles in Chapter 3.

Exception No. 1: The provisions of 725.48 through 725.51 shall be permitted to apply in installations of Class 1 circuits.

Exception No. 2: Methods permitted or required by other articles of this Code shall apply to installations of Class 1 circuits.

725.48 Conductors of Different Circuits in the Same Cable, Cable Tray, Enclosure, or Raceway

Class 1 circuits shall be permitted to be installed with other circuits as specified in 725.48(A) and (B).

(A) Two or More Class 1 Circuits

Class 1 circuits shall be permitted to occupy the same cable, cable tray, enclosure, or raceway without regard to whether the individual circuits are alternating current or direct current, provided all conductors are insulated for the maximum voltage of any conductor in the cable, cable tray, enclosure, or raceway.

(B) Class 1 Circuits With Power-Supply Circuits

Class 1 circuits shall be permitted to be installed with power-supply conductors as specified in 725.48(B)(1) through (B)(4).

(1) In a Cable, Enclosure, or Raceway

Class 1 circuits and power-supply circuits shall be permitted to occupy the same cable, enclosure, or raceway without a barrier only where the equipment powered is functionally associated. Class 1 circuits shall be permitted to be installed together with the conductors of electric light, power, non-power-limited fire alarm, and medium power network-powered broadband communications circuits where separated by a barrier.

(2) In Factory- or Field-Assembled Control Centers

Class 1 circuits and power-supply circuits shall be permitted to be installed in factory- or field-assembled control centers.

(3) In a Manhole

Class 1 circuits and power-supply circuits shall be permitted to be installed as underground conductors in a manhole in accordance with one of the following:

The power-supply or Class 1 circuit conductors are in a metal-enclosed cable or Type UF cable.

The conductors are permanently separated from the power-supply conductors by a continuous firmly fixed nonconductor, such as flexible tubing, in addition to the insulation on the wire.

The conductors are permanently and effectively separated from the power supply conductors and securely fastened to racks, insulators, or other approved supports.

(4) In Cable Trays

Installations in cable trays shall comply with 725.48(B)(4)(1) or (B)(4)(2).

Class 1 circuit conductors and power-supply conductors not functionally associated with the Class 1 circuit conductors shall be separated by a solid fixed barrier of a material compatible with the cable tray.

Class 1 circuit conductors and power-supply conductors not functionally associated with the Class 1 circuit conductors shall be permitted to be installed in a cable tray without barriers where all of the conductors are installed with separate multiconductor Type AC, Type MC, Type MI, or Type TC cables and all the conductors in the cables are insulated at 600 volts or greater.

725.49 Class 1 Circuit Conductors

(A) Sizes and Use

Conductors of sizes 18 AWG and 16 AWG shall be permitted to be used, provided they supply loads that do not exceed the ampacities given in 402.5 and are installed in a raceway, an approved enclosure, or a listed cable. Conductors larger than 16 AWG shall not supply loads greater than the ampacities given in 310.14. Flexible cords shall comply with Article 400.

(B) Insulation

Insulation on conductors shall be rated for the system voltage and not less than 600 volts. Conductors larger than 16 AWG shall comply with Article 310. Conductors in sizes 18 AWG and 16 AWG shall be Type FFH-2, KF-2, KFF-2, PAF, PAFF, PF, PFF, PGF, PGFF, PTF, PTFF, RFH-2, RFHH-2, RFHH-3, SF-2, SFF-2, TF, TFF, TFFN, TFN, ZF, or ZFF. Conductors with other types and thicknesses of insulation shall be permitted if listed for Class 1 circuit use.

725.51 Number of Conductors in Cable Trays and Raceway, and Ampacity Adjustment

(A) Class 1 Circuit Conductors

Where only Class 1 circuit conductors are in a raceway, the number of conductors shall be determined in accordance with 300.17. The ampacity adjustment factors given in 310.15(C)(1) shall apply only if such conductors carry continuous loads in excess of 10 percent of the ampacity of each conductor.

(B) Power-Supply Conductors and Class 1 Circuit Conductors

Where power-supply conductors and Class 1 circuit conductors are permitted in a raceway in accordance with 725.48, the number of conductors shall be determined in accordance with 300.17. The ampacity adjustment factors given in 310.15(C)(1) shall apply as follows:

To all conductors where the Class 1 circuit conductors carry continuous loads in excess of 10 percent of the ampacity of each conductor and where the total number of conductors is more than three

To the power-supply conductors only, where the Class 1 circuit conductors do not carry continuous loads in excess of 10 percent of the ampacity of each conductor and where the number of power-supply conductors is more than three

(C) Class 1 Circuit Conductors in Cable Trays

Where Class 1 circuit conductors are installed in cable trays, they shall comply with the provisions of 392.22 and 392.80(A).

725.52 Circuits Extending Beyond One Building

Class 1 circuits that extend aerially beyond one building shall also meet the requirements of Article 225.

Part III Class 2 and Class 3 Circuits

725.121 Power Sources for Class 2 and Class 3 Circuits

Informational Note Figure 725.121 Class 2 and Class 3 Circuits.

(A) Power Source

The power source for a Class 2 or a Class 3 circuit shall be as follows:

Informational Note No. 1: Informational Note Figure 725.121 illustrates the relationships between Class 2 or Class 3 power sources, their supply, and the Class 2 or Class 3 circuits.

Informational Note No. 2: Table 11(A) and Table 11(B) in Chapter 9 provide the requirements for listed Class 2 and Class 3 power sources.

A listed Class 2 or Class 3 transformer

A listed Class 2 or Class 3 power supply

Other listed equipment marked to identify the Class 2 or Class 3 power source

Exception No. 1 to (3): Thermocouples shall not require listing as a Class 2 power source.

Exception No. 2 to (3): Limited power circuits of listed equipment where these circuits have energy levels rated at or below the limits established in Chapter 9, Table 11(A) and Table 11(B).

Informational Note: Examples of other listed equipment are as follows:

A circuit card listed for use as a Class 2 or Class 3 power source where used as part of a listed assembly

A current-limiting impedance, listed for the purpose, or part of a listed product, used in conjunction with a non-power-limited transformer or a stored energy source, for example, storage battery, to limit the output current

A thermocouple

Limited voltage/current or limited impedance secondary communications circuits of listed industrial control equipment

Listed audio/video, information technology (computer), communications, and industrial equipment limited-power circuits

Informational Note: One way to determine applicable requirements for listing of information technology (computer) equipment is to refer to UL 60950-1-2011, Standard for Safety of Information Technology Equipment. Another way to determine applicable requirements for listing of audio/video, information technology, and communications equipment is to refer to UL 62368-1-2014, Safety of audio/video, information and communication technology equipment. Typically such circuits are used to interconnect data circuits for the purpose of exchanging information data. One way to determine applicable requirements for listing of industrial equipment is to refer to UL 61010-2-201, Safety requirements for electrical equipment for measurement, control, and laboratory use — Part 2—201: Particular requirements for control equipment, and/or UL 61800-5-1, Adjustable speed electrical power drive systems — Part 5-1: Safety requirements — Electrical, thermal and energy.

A battery source or battery source system that is listed and identified as Class 2

(B) Interconnection of Power Sources

Class 2 or Class 3 power sources shall not have the output connections paralleled or otherwise interconnected unless listed for such interconnection.

(C) Marking

The power sources for limited power circuits in 725.121(A)(3), limited power circuits for listed audio/video equipment, listed information technology equipment, listed communications equipment, and listed industrial equipment in 725.121(A)(4) shall have a label indicating the maximum voltage and rated current output per conductor for each point on the power source. Where multiple connection points have the same rating, a single label shall be permitted to be used. For equipment with a rated current per conductor less than 0.3 amperes, the effective date shall be January 1, 2021.

Informational Note No. 1: Rated current for power sources covered in 725.144 is the output current per conductor the power source is designed to deliver to an operational load at normal operating conditions, as declared by the manufacturer.

Informational Note No. 2: An example of a label is "52V @ 0.433A, 57V MAX" for an IEEE 802.3 compliant Class 8 power source.

725.124 Circuit Marking

The equipment supplying the circuits shall be durably marked where plainly visible to indicate each circuit that is a Class 2 or Class 3 circuit.

725.127 Wiring Methods on Supply Side of the Class 2 or Class 3 Power Source

Conductors and equipment on the supply side of the power source shall be installed in accordance with the appropriate requirements of Chapters 1 through 4. Transformers or other devices supplied from electric light or power circuits shall be protected by an overcurrent device rated not over 20 amperes.

Exception: The input leads of a transformer or other power source supplying Class 2 and Class 3 circuits shall be permitted to be smaller than 14 AWG, but not smaller than 18 AWG if they are not over 305 mm (12 in.) long and if they have insulation that complies with 725.49(B).

725.130 Wiring Methods and Materials on Load Side of the Class 2 or Class 3 Power Source

Class 2 and Class 3 circuits on the load side of the power source shall be permitted to be installed using wiring methods and materials in accordance with either 725.130(A) or (B).

(A) Class 1 Wiring Methods and Materials

Installation shall be in accordance with 725.46.

Exception No. 1: The ampacity adjustment factors given in 310.15(C)(1) shall not apply.

Exception No. 2: Class 2 and Class 3 circuits shall be permitted to be reclassified and installed as Class 1 circuits if the Class 2 and Class 3 markings required in 725.124 are eliminated and the entire circuit is installed using the wiring methods and materials in accordance with Part II, Class 1 circuits.

Informational Note: Class 2 and Class 3 circuits reclassified and installed as Class 1 circuits are no longer Class 2 or Class 3 circuits, regardless of the continued connection to a Class 2 or Class 3 power source.

(B) Class 2 and Class 3 Wiring Methods

Conductors on the load side of the power source shall be insulated at not less than the requirements of 725.179 and shall be installed in accordance with 725.133 and 725.154.

Exception No. 1: As provided for in 620.21 for elevators and similar equipment.

Exception No. 2: Other wiring methods and materials installed in accordance with the requirements of 725.3 shall be permitted to extend or replace the conductors and cables described in 725.179 and permitted by 725.130(B).

Exception No. 3: Bare Class 2 conductors shall be permitted as part of a listed intrusion protection system where installed in accordance with the listing instructions for the system.

725.133 Installation of Conductors and Equipment in Cables, Compartments, Cable Trays, Enclosures, Manholes, Outlet Boxes, Device Boxes, Raceways, and Cable Routing Assemblies for Class 2 and Class 3 Circuits

Conductors and equipment for Class 2 and Class 3 circuits shall be installed in accordance with 725.135 through 725.144.

725.135 Installation of Class 2, Class 3, and PLTC Cables

Installation of Class 2, Class 3, and PLTC cables shall comply with 725.135(A) through (M).

(A) Listing

Class 2, Class 3, and PLTC cables installed in buildings shall be listed.

(B) Ducts Specifically Fabricated for Environmental Air

The following cables shall be permitted in ducts specifically fabricated for environmental air as described in 300.22(B) if directly associated with the air distribution system:

Types CL2P and CL3P cables in lengths as short as practicable to perform the required function

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, CL2X, CL3X, and PLTC cables installed in raceways that are installed in compliance with 300.22(B)

Informational Note: For information on fire protection of wiring installed in fabricated ducts, see 4.3.4.1 and 4.3.11.3.3 of NFPA 90A-2018, Standard for the Installation of Air-Conditioning and Ventilating Systems.

(C) Other Spaces Used for Environmental Air (Plenums)

The following cables shall be permitted in other spaces used for environmental air as described in 300.22(C):

Types CL2P and CL3P cables

Types CL2P and CL3P cables installed in plenum communications raceways

Types CL2P and CL3P cables installed in plenum cable routing assemblies

Types CL2P and CL3P cables and plenum communications raceways supported by open metallic cable trays or cable tray systems

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, CL2X, CL3X, and PLTC cables installed in raceways that are installed in compliance with 300.22(C)

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, CL2X, CL3X, and PLTC cables supported by solid bottom metal cable trays with solid metal covers in other spaces used for environmental air (plenums) as described in 300.22(C)

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, CL2X, CL3X, and PLTC cables installed in plenum communications raceways, riser communications raceways, and general-purpose communications raceways supported by solid bottom metal cable trays with solid metal covers in other spaces used for environmental air (plenums) as described in 300.22(C)

(D) Risers — Cables in Vertical Runs

The following cables shall be permitted in vertical runs penetrating one or more floors and in vertical runs in a shaft:

Types CL2P, CL3P, CL2R, and CL3R cables

Types CL2P, CL3P, CL2R, and CL3R cables installed in the following:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

Informational Note: See 300.21 for firestop requirements for floor penetrations.

(E) Risers — Cables and Innerducts in Metal Raceways

The following cables shall be permitted in metal raceways in a riser having firestops at each floor:

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, CL2X, CL3X, and PLTC cables

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, CL2X, CL3X, and PLTC cables installed in the following:

Plenum communications raceways (innerduct)

Riser communications raceways (innerduct)

General-purpose communications raceways (innerduct)

Informational Note: See 300.21 for firestop requirements for floor penetrations.

(F) Risers — Cables in Fireproof Shafts

The following shall be permitted to be installed in fireproof riser shafts having firestops at each floor:

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, CL2X, CL3X, and PLTC cables

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables installed in the following:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

Informational Note: See 300.21 for firestop requirements for floor penetrations.

(G) Risers — One- And Two-Family Dwellings

The following cables shall be permitted in one- and two-family dwellings:

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables

Types CL2X and CL3X cables less than 6 mm (0.25 in.) in diameter

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables installed in the following:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

(H) Cable Trays

Cables installed in cable trays outdoors shall be Type PLTC. The following cables shall be permitted to be supported by cable trays in buildings:

Types CM CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables installed in the following:

Plenum communications raceways

Riser communications raceways

General-purpose communications raceways

(I) Cross-Connect Arrays

The following cables shall be permitted to be installed in cross-connect arrays:

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables installed in the following:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

(J) Industrial Establishments

In industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons service the installation, Type PLTC cable shall be permitted in accordance with either (1) or (2) as follows:

Where the cable is not subject to physical damage, Type PLTC cable that complies with the crush and impact requirements of Type MC cable and is identified as PLTC-ER for such use shall be permitted to be exposed between the cable tray and the utilization equipment or device. The cable shall be continuously supported and protected against physical damage using mechanical protection such as dedicated struts, angles, or channels. The cable shall be supported and secured at intervals not exceeding 1.8 m (6 ft). Where not subject to physical damage, Type PLTC-ER cable shall be permitted to transition between cable trays and between cable trays and utilization equipment or devices for a distance not to exceed 1.8 m (6 ft) without continuous support. The cable shall be mechanically supported where exiting the cable tray to ensure that the minimum bending radius is not exceeded.

Type PLTC cable, with a metallic sheath or armor in accordance with 725.179(E), shall be permitted to be installed exposed. The cable shall be continuously supported and protected against physical damage using mechanical protection such as dedicated struts, angles, or channels. The cable shall be secured at intervals not exceeding 1.8 m (6 ft).

(K) Other Building Locations

The following cables shall be permitted to be installed in building locations other than the locations covered in 725.135(B) through (I):

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables

A maximum of 3 m (10 ft) of exposed Type CL2X cables in nonconcealed spaces

A maximum of 3 m (10 ft) of exposed Type CL3X cables in nonconcealed spaces

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables installed in the following:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, CL2X, CL3X, and PLTC cables installed in raceways recognized in Chapter 3

Type CMUC under-carpet communications wires and cables installed under carpet, modular flooring, and planks

(L) Multifamily Dwellings

The following cables shall be permitted to be installed in multifamily dwellings in locations other than the locations covered in 725.135(B) through (I):

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables

Type CL2X cables less than 6 mm (1/4 in.) in diameter in nonconcealed spaces

Type CL3X cables less than 6 mm (1/4 in.) in diameter in nonconcealed spaces

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables installed in the following:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, CL2X, CL3X, and PLTC wires and cables installed in raceways recognized in Chapter 3

Type CMUC under-carpet communications wires and cables installed under carpet, modular flooring, and planks

(M) One- And Two-Family Dwellings

The following cables shall be permitted to be installed in one- and two-family dwellings in locations other than the locations covered in 725.135(B) through (I):

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables

Type CL2X cables less than 6 mm (1/4 in.) in diameter

Type CL3X cables less than 6 mm (1/4 in.) in diameter

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, and PLTC cables installed in the following:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

Types CL2P, CL3P, CL2R, CL3R, CL2, CL3, CL2X, CL3X, and PLTC cables installed in raceways recognized in Chapter 3

Type CMUC under-carpet communications cables installed under carpet, modular flooring, and planks

725.136 Separation From Electric Light, Power, Class 1, Non—Power-Limited Fire Alarm Circuit Conductors, and Medium-Power Network-Powered Broadband Communications Cables

(A) General

Cables and conductors of Class 2 and Class 3 circuits shall not be placed in any cable, cable tray, compartment, enclosure, manhole, outlet box, device box, raceway, or similar fitting with conductors of electric light, power, Class 1, non—power-limited fire alarm circuits, and medium-power network-powered broadband communications circuits unless permitted by 725.136(B) through (I).

(B) Separated by Barriers

Class 2 and Class 3 circuits shall be permitted to be installed together with the conductors of electric light, power, Class 1, non—power-limited fire alarm and medium power network-powered broadband communications circuits where they are separated by a barrier.

(C) Raceways Within Enclosures

In enclosures, Class 2 and Class 3 circuits shall be permitted to be installed in a raceway to separate them from Class 1, non—power-limited fire alarm and medium-power network-powered broadband communications circuits.

(D) Associated Systems Within Enclosures

Class 2 and Class 3 circuit conductors in compartments, enclosures, device boxes, outlet boxes, or similar fittings shall be permitted to be installed with electric light, power, Class 1, non—power-limited fire alarm, and medium-power network-powered broadband communications circuits where they are introduced solely to connect the equipment connected to Class 2 and Class 3 circuits, and where (1) or (2) applies:

The electric light, power, Class 1, non—power-limited fire alarm, and medium-power network-powered broadband communications circuit conductors are routed to maintain a minimum of 6 mm (0.25 in.) separation from the conductors and cables of Class 2 and Class 3 circuits.

The circuit conductors operate at 150 volts or less to ground and also comply with one of the following:

The Class 2 and Class 3 circuits are installed using Type CL3, CL3R, or CL3P or permitted substitute cables, provided these Class 3 cable conductors extending beyond the jacket are separated by a minimum of 6 mm (0.25 in.) or by a nonconductive sleeve or nonconductive barrier from all other conductors.

The Class 2 and Class 3 circuit conductors are installed as a Class 1 circuit in accordance with 725.41.

(E) Enclosures With Single Opening

Class 2 and Class 3 circuit conductors entering compartments, enclosures, device boxes, outlet boxes, or similar fittings shall be permitted to be installed with Class 1, non—power-limited fire alarm and medium-power network-powered broadband communications circuits where they are introduced solely to connect the equipment connected to Class 2 and Class 3 circuits. Where Class 2 and Class 3 circuit conductors must enter an enclosure that is provided with a single opening, they shall be permitted to enter through a single fitting (such as a tee), provided the conductors are separated from the conductors of the other circuits by a continuous and firmly fixed nonconductor, such as flexible tubing.

(F) Manholes

Underground Class 2 and Class 3 circuit conductors in a manhole shall be permitted to be installed with Class 1, non—power-limited fire alarm and medium-power network-powered broadband communications circuits where one of the following conditions is met:

The electric light, power, Class 1, non—power-limited fire alarm and medium-power network-powered broadband communications circuit conductors are in a metal-enclosed cable or Type UF cable.

The Class 2 and Class 3 circuit conductors are permanently and effectively separated from the conductors of other circuits by a continuous and firmly fixed nonconductor, such as flexible tubing, in addition to the insulation or covering on the wire.

The Class 2 and Class 3 circuit conductors are permanently and effectively separated from conductors of the other circuits and securely fastened to racks, insulators, or other approved supports.

(G) Cable Trays

Class 2 and Class 3 circuit conductors shall be permitted to be installed in cable trays, where the conductors of the electric light, Class 1, and non—power-limited fire alarm circuits are separated by a solid fixed barrier of a material compatible with the cable tray or where the Class 2 or Class 3 circuits are installed in Type MC cable.

(H) In Hoistways

In hoistways, Class 2 or Class 3 circuit conductors shall be installed in rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible nonmetallic conduit, or electrical metallic tubing. For elevators or similar equipment, these conductors shall be permitted to be installed as provided in 620.21.

(I) Other Applications

For other applications, conductors of Class 2 and Class 3 circuits shall be separated by at least 50 mm (2 in.) from conductors of any electric light, power, Class 1 non—power-limited fire alarm or medium power network-powered broadband communications circuits unless one of the following conditions is met:

Either all of the electric light, power, Class 1, non—power-limited fire alarm and medium-power network-powered broadband communications circuit conductors or all of the Class 2 and Class 3 circuit conductors are in a raceway or in metal-sheathed, metal-clad, non—metallic-sheathed, Type TC, or Type UF cables

All of the electric light, power, Class 1 non—power-limited fire alarm, and medium-power network-powered broadband communications circuit conductors are permanently separated from all of the Class 2 and Class 3 circuit conductors by a continuous and firmly fixed nonconductor, such as porcelain tubes or flexible tubing, in addition to the insulation on the conductors

725.139 Installation of Conductors of Different Circuits in the Same Cable, Enclosure, Cable Tray, Raceway, or Cable Routing Assembly

(A) Two or More Class 2 Circuits

Conductors of two or more Class 2 circuits shall be permitted within the same cable, enclosure, raceway, or cable routing assembly.

(B) Two or More Class 3 Circuits

Conductors of two or more Class 3 circuits shall be permitted within the same cable, enclosure, raceway, or cable routing assembly.

(C) Class 2 Circuits With Class 3 Circuits

Conductors of one or more Class 2 circuits shall be permitted within the same cable, enclosure, raceway, or cable routing assembly with conductors of Class 3 circuits, provided that the insulation of the Class 2 circuit conductors in the cable, enclosure, raceway, or cable routing assembly is at least that required for Class 3 circuits.

(D) Class 2 and Class 3 Circuits With Communications Circuits

(1) Communications Cables

Conductors of one or more Class 2 or Class 3 circuits shall be permitted in the same cable with conductors of communications circuits provided the cable is a listed communications cable that shall be installed in accordance with the requirements of Part V of Article 805. The cables shall be listed as communications cables.

(2) Composite Cables

Cables constructed of individually listed Class 2, Class 3, and communications cables under a common jacket shall be permitted to be classified as communications cables. The fire resistance rating of the composite cable shall be determined by the performance of the composite cable.

(E) Class 2 or Class 3 Cables With Other Circuit Cables

Jacketed cables of Class 2 or Class 3 circuits shall be permitted in the same enclosure, cable tray, raceway, or cable routing assembly with jacketed cables of any of the following:

Power-limited fire alarm systems in compliance with Parts I and III of Article 760

Nonconductive and conductive optical fiber cables in compliance with Parts I and IV of Article 770

Communications circuits in compliance with Parts I and IV of Article 805

Community antenna television and radio distribution systems in compliance with Parts I and IV of Article 820

Low-power, network-powered broadband communications in compliance with Parts I and IV of Article 830

(F) Class 2 or Class 3 Conductors or Cables and Audio System Circuits

Audio system circuits described in 640.9(C), and installed using Class 2 or Class 3 wiring methods in compliance with 725.133 and 725.154, shall not be permitted to be installed in the same cable, raceway, or cable routing assembly with Class 2 or Class 3 conductors or cables.

725.141 Installation of Circuit Conductors Extending Beyond One Building

Where Class 2 or Class 3 circuit conductors extend beyond one building and are run so as to be subject to accidental contact with electric light or power conductors operating over 300 volts to ground, or are exposed to lightning on interbuilding circuits on the same premises, the requirements of the following shall also apply:

Sections 800.44, 800.53, 800.100, 805.50, 805.93, 805.170(A), and 805.170(B) for other than coaxial conductors

Sections 820.44, 820.93, and 820.100 for coaxial conductors

725.143 Support of Conductors

Class 2 or Class 3 circuit conductors shall not be strapped, taped, or attached by any means to the exterior of any conduit or other raceway as a means of support. These conductors shall be permitted to be installed as permitted by 300.11(C)(2).

725.144 Transmission of Power and Data

Sections 725.144(A) and (B) shall apply to Class 2 and Class 3 circuits that transmit power and data to a powered device. Section 300.11 and Parts I and III of Article 725 shall apply to Class 2 and Class 3 circuits that transmit power and data. The conductors that carry power for the data circuits shall be copper. The current in the power circuit shall not exceed the current limitation of the connectors.

Informational Note No. 1: One example of the use of cables that transmit power and data is the connection of closed-circuit TV cameras (CCTV).

Informational Note No. 2: The 8P8C connector is in widespread use with powered communications systems. IEC 60603-7-2008, Connectors for electronic equipment — Part 7-1: Detail specification for 8-way, unshielded, free and fixed connectors, specifies these connectors to have a current-carrying capacity per contact of 1.0 amperes maximum at 60°C (149°F). See IEC 60603-7 for more information on current-carrying capacity at higher and lower temperatures.

Informational Note No. 3: The requirements of Table 725.144 were derived for carrying power and data over 4-pair copper balanced twisted pair cabling. This type of cabling is described in ANSI/TIA 568-C.2-2009, Commercial Building Telecommunications Cabling Standard — Part 2: Balanced Twisted-Pair Telecommunications Cabling and Components.

Informational Note No. 4: See TIA-TSB-184-A-2017, Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling, for information on installation and management of balanced twisted pair cabling supporting power delivery.

Informational Note No. 5: See ANSI/NEMA C137.3-2017, American National Standard for Lighting Systems — Minimum Requirements for Installation of Energy Efficient Power over Ethernet (PoE) Lighting Systems, for information on installation of cables for PoE lighting systems.

Informational Note No. 6: Rated current for power sources covered in 725.144 is the output current per conductor the power source is designed to deliver to an operational load at normal operating conditions, as declared by the manufacturer. In the design of these systems, the actual current in a given conductor might vary from the rated current per conductor by as much as 20 percent. An increase in current in one conductor is offset by a corresponding decrease in current in one or more conductors of the same cable.

Table 725.144 Ampacities of Each Conductor in Amperes in 4-Pair Class 2 or Class 3 Balanced Twisted-Pair Cables Based on Copper Conductors at an Ambient Temperature of 30°C (86°F) with All Conductors in All Cables Carrying Current, 60°C (140°F), 75°C (167°F), and 90°C (194°F) Rated Cables

AWG Number of 4-Pair Cables in a Bundle

1—7 8—19 20—37 38—61 62—91 92—192

Temperature Rating Temperature Rating Temperature Rating Temperature Rating Temperature Rating Temperature Rating

60°C 75°C 90°C 60°C 75°C 90°C 60°C 75°C 90"C 60°C 75°C 90°C 60°C 75°C 90°C 60°C 75°C 90°C

26 1.00 1.23 1.42 0.71 0.87 1.02 0.55 0.68 0.78 0.46 0.57 0.67 0.45 0.55 0.64 NA NA NA

24 1.19 1.46 1.69 0.81 1.01 1.17 0.63 0.78 0.91 0.55 0.67 0.78 0.46 0.56 0.65 0.40 0.48 0.55

23 1.24 1.53 1.78 0.89 1.11 1.28 0.77 0.95 1.10 0.66 0.80 0.93 0.58 0.71 0.82 0.45 0.55 0.63

22 1.50 1.86 2.16 1.04 1.28 1.49 0.77 0.95 1.11 0.66 0.82 0.96 0.62 0.77 0.89 0.53 0.63 0.72

Note 1: For bundle sizes over 192 cables, or for conductor sizes smaller than 26 AWG, ampacities shall be permitted to be determined by qualified personnel under engineering supervision.

Note 2: Where only half of the conductors in each cable are carrying current, the values in the table shall be permitted to be increased by a factor of 1.4.

Informational Note No. 1: Elevated cable temperatures can reduce a cable's data transmission performance. For information on practices for 4-pair balanced twisted pair cabling, see TIA-TSB-184-A and 6.4.7, 6.6.3, and Annex G of ANSI/TIA-568-C.2, which provide guidance on adjustments for operating temperatures between 20°C and 60°C.

Informational Note No. 2: The per-contact current rating of connectors can limit the maximum allowable current below the ampacity shown in Table 725.144.

(A) Use of Class 2 or Class 3 Cables to Transmit Power and Data

Where Types CL3P, CL2P, CL3R, CL2R, CL3, or CL2 transmit power and data, the rated current per conductor of the power source shall not exceed the ampacities in Table 725.144 at an ambient temperature of 30°C (86°F). For ambient temperatures above 30°C (86°F), the correction factors in Table 310.15(B)(1) or in Equation 310.15(B) shall apply.

Exception: Compliance with Table 725.144 shall not be required for installations where conductors are 24 AWG or larger and the rated current per conductor of the power source does not exceed 0.3 amperes.

Informational Note: One example of the use of Class 2 cables is a network of closed-circuit TV cameras using 24 AWG, 60°C rated, Type CL2R, Category 5e balanced twisted-pair cabling.

(B) Use of Class 2-LP or Class 3-LP Cables to Transmit Power and Data

Types CL3P-LP, CL2P-LP, CL3R-LP, CL2R-LP, CL3-LP, or CL2-LP shall be permitted to supply power to equipment from a power source with a rated current per conductor up to the marked current limit located immediately following the suffix "-LP" and shall be permitted to transmit data to the equipment. Where the number of bundled LP cables is 192 or less and the selected ampacity of the cables in accordance with Table 725.144 exceeds the marked current limit of the cable, the ampacity determined from the table shall be permitted to be used. For ambient temperatures above 30°C (86°F), the correction factors of Table 310.15(B)(1) or Equation 310.15(B) shall apply. The Class 2-LP and Class 3-LP cables shall comply with the following, as applicable:

Cables with the suffix "-LP" shall be permitted to be installed in bundles, raceways, cable trays, communications raceways, and cable routing assemblies.

Cables with the suffix "-LP" and a marked current limit shall follow the substitution hierarchy of Table 725.154 and Figure 725.154(A) for the cable type without the suffix "-LP" and without the marked current limit.

System design shall be permitted by qualified persons under engineering supervision.

Informational Note: An example of a limited power (LP) cable is a cable marked Type CL2-LP(0.5A), 23 AWG.

725.154 Applications of Listed Class 2, Class 3, and PLTC Cables

Class 2, Class 3, and PLTC cables shall comply with any of the requirements described in 725.154(A) through (C) and as indicated in Table 725.154.

Table 725.154 Applications of Listed Class 2, Class 3, CMUC, and PLTC Cables in Buildings

Applications Cable Type

CL2P & CL3P CL2R & CL3R CL2 & CL3 CL2X & CL3X CMUC PLTC

In fabricated ducts as described in 300.22(B) In fabricated ducts Y\* N N N N N

In metal raceway that complies with 300.22(B) Y\* Y\* Y\* Y\* N Y\*

In other spaces used for environmental air as described in 300.22(C) In other spaces used for environmental air Y\* N N N N N

In metal raceway that complies with 300.22(C) Y\* Y\* Y\* Y\* N Y\*

In plenum communications raceways Y\* N N N N N

In plenum cable routing assemblies Y\* N N N N N

Supported by open metal cable trays Y\* N N N N N

Supported by solid bottom metal cable trays with solid metal covers Y\* Y\* Y\* Y\* N N

In risers In vertical runs Y\* Y\* N N N N

In metal raceways Y\* Y\* Y\* Y\* N Y\*

In fireproof shafts Y\* Y\* Y\* Y\* N Y\*

In plenum communications raceways Y\* Y\* N N N N

In plenum cable routing assemblies Y\* Y\* N N N N

In riser communications raceways Y\* Y\* N N N N

In riser cable routing assemblies Y\* Y\* N N N N

In one- and two-family dwellings Y\* Y\* Y\* Y\* N Y\*

Within buildings in other than air-handling spaces and risers General Y\* Y\* Y\* Y\* N Y\*

In one- and two-family dwellings Y\* Y\* Y\* Y\* Y\* Y\*

In multifamily dwellings Y\* Y\* Y\* Y\* Y\* Y\*

In nonconcealed spaces Y\* Y\* Y\* Y\* Y\* Y\*

Supported by cable trays Y\* Y\* Y\* N N Y\*

Under carpet N N N N Y\* N

In cross-connect arrays Y\* Y\* Y\* N N Y\*

In any raceway recognized in Chapter 3 Y\* Y\* Y\* Y\* N Y\*

In plenum communications raceways Y\* Y\* Y\* N N Y\*

In plenum cable routing assemblies Y\* Y\* Y\* N N Y\*

In riser communications raceways Y\* Y\* Y\* N N Y\*

In riser cable routing assemblies Y\* Y\* Y\* N N Y\*

In general-purpose communications raceways Y\* Y\* Y\* N N Y\*

In general-purpose cable routing assemblies Y\* Y\* Y\* N N Y\*

Note: "N" indicates that the cable type shall not be permitted to be installed in the application.

"Y\*" indicates that the cable type shall be permitted to be installed in the application, subject to the limitations described in 725.130 through 725.143.

(A) Class 2 and Class 3 Cable Substitutions

The substitutions for Class 2 and Class 3 cables listed in Table 725.154(A) and illustrated in Figure 725.154(A) shall be permitted. Where substitute cables are installed, the wiring requirements of Article 725, Parts I and III, shall apply.

Informational Note: For information on Types CMP, CMR, CM, and CMX, see 805.179.

Table 725.154(A) Cable Substitutions

Cable Type Permitted Substitutions

CL3P CMP

CL2P CMP, CL3P

CL3R CMP, CL3P, CMR

CL2R CMP, CL3P, CL2P, CMR, CL3R

PLTC

CL3 CMP, CL3P, CMR, CL3R, CMG, CM, PLTC

CL2 CMP, CL3P, CL2P, CMR, CL3R, CL2R, CMG, CM, PLTC, CL3

CL3X CMP, CL3P, CMR, CL3R, CMG, CM, PLTC, CL3, CMX

CL2X CMP, CL3P, CL2P, CMR, CL3R, CL2R, CMG, CM, PLTC, CL3, CL2, CMX, CL3X

FIGURE 725.154(A) Cable Substitution Hierarchy.

(B) Class 2, Class 3, PLTC Circuit Integrity (CI) Cable or Electrical Circuit Protective System

Circuit integrity (CI) cable or a listed electrical circuit protective system shall be permitted for use in remote control, signaling, or power-limited systems that supply critical circuits to ensure survivability for continued circuit operation for a specified time under fire conditions.

(C) Thermocouple Circuits

Conductors in Type PLTC cables used for Class 2 thermocouple circuits shall be permitted to be any of the materials used for thermocouple extension wire.

Part IV Listing Requirements

725.170 Listing and Marking of Equipment for Power and Data Transmission

The listed power source for circuits intended to provide power and data over Class 2 cables to remote equipment shall be as specified in 725.121(A)(1), (A)(2), (A)(3), or (A)(4). In accordance with 725.121(B), the power sources shall not have the output connections paralleled or otherwise interconnected, unless listed for such interconnection. Powered devices connected to a circuit supplying data and power shall be listed. Marking of equipment output connections shall be in accordance with 725.121(C).

725.179 Listing and Marking of Class 2, Class 3, and Type PLTC Cables

Class 2, Class 3, and Type PLTC cables, installed as wiring methods within buildings, shall be listed as resistant to the spread of fire and other criteria in accordance with 725.179(A) through (I), shall be marked in accordance with 725.179(J), and shall be permitted to be marked in accordance with 725.179(K).

(A) Types CL2P and CL3P

Types CL2P and CL3P plenum cable shall be listed as suitable for use in ducts, plenums, and other space for environmental air and shall be listed as having adequate fire-resistant and low-smoke producing characteristics.

Informational Note: One method of defining a cable that is low-smoke producing and fire resistant is that the cable exhibits a maximum peak optical density of 0.50 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.52 m (5 ft) or less when tested in accordance with NFPA 262-2019, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

(B) Types CL2R and CL3R

Types CL2R and CL3R riser cables shall be marked as Type CL2R or CL3R, respectively, and be listed as suitable for use in a vertical run in a shaft or from floor to floor and shall be listed as having fire-resistant characteristics capable of preventing the carrying of fire from floor to floor.

Informational Note: One method of defining fire-resistant characteristics capable of preventing the carrying of fire from floor to floor is that the cables pass the requirements of ANSI/UL 1666-2012, Test for Flame Propagation Height of Electrical and Optical-Fiber Cable Installed Vertically in Shafts.

(C) Types CL2 and CL3

Types CL2 and CL3 cables shall be marked as Type CL2 or CL3, respectively, and be listed as suitable for general-purpose use, with the exception of risers, ducts, plenums, and other space used for environmental air, and shall be listed as resistant to the spread of fire.

Informational Note: One method of defining resistant to the spread of fire is that the cables do not spread fire to the top of the tray in the UL flame exposure, vertical tray flame test in ANSI/UL 1685-2010, Standard for Safety for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables. The smoke measurements in the test method are not applicable.

Another method of defining resistant to the spread of fire is for the damage (char length) not to exceed 1.5 m (4 ft 11 in.) when performing the CSA vertical flame test for cables in cable trays, as described in CSA C22.2 No. 0.3-M-2001, Test Methods for Electrical Wires and Cables.

(D) Types CL2X and CL3X

Types CL2X and CL3X limited-use cables shall be marked as Type CL2X or CL3X, and be listed as suitable for use in dwellings and raceways and shall be listed as resistant to flame spread.

Informational Note: One method of determining that cable is resistant to flame spread is by testing the cable to the VW-1 (vertical wire) flame test in ANSI/UL 1581-2011, Reference Standard for Electrical Wires, Cables and Flexible Cords.

(E) Type PLTC

Type PLTC nonmetallic-sheathed, power-limited tray cable shall be listed as being suitable for cable trays and shall consist of a factory assembly of two or more insulated conductors under a nonmetallic jacket. The insulated conductors shall be 22 AWG through 12 AWG. The conductor material shall be copper (solid or stranded). Insulation on conductors shall be rated for 300 volts. The cable core shall be two or more parallel conductors, one or more group assemblies of twisted or parallel conductors, or a combination thereof. A metallic shield or a metallized foil shield with drain wire(s) shall be permitted to be applied over the cable core, over groups of conductors, or both. The cable shall be listed as resistant to the spread of fire. The outer jacket shall be a sunlight- and moisture-resistant nonmetallic material. Type PLTC cable used in a wet location shall be listed for use in wet locations or have a moisture-impervious metal sheath.

Exception No. 1: Where a smooth metallic sheath, continuous corrugated metallic sheath, or interlocking tape armor is applied over the nonmetallic jacket, an overall nonmetallic jacket shall not be required. On metallic-sheathed cable without an overall nonmetallic jacket, the information required in 310.8 shall be located on the nonmetallic jacket under the sheath.

Exception No. 2: Conductors in PLTC cables used for Class 2 thermocouple circuits shall be permitted to be any of the materials used for thermocouple extension wire.

Informational Note: One method of defining resistant to the spread of fire is that the cables do not spread fire to the top of the tray in the UL flame exposure, vertical tray flame test in ANSI/UL 1685-2010, Standard for Safety for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables. The smoke measurements in the test method are not applicable.

Another method of defining resistant to the spread of fire is for the damage (char length) not to exceed 1.5 m (4 ft 11 in.) when performing the CSA vertical tray flame test for cables in cable trays, as described in CSA C22.2 No. 0.3-M-2001, Test Methods for Electrical Wires and Cables.

(F) Circuit Integrity (CI) Cable or Electrical Circuit Protective System

Cables that are used for survivability of critical circuits under fire conditions shall meet the requirements of either 725.179(F)(1) or (F)(2).

(1) Circuit Integrity (CI) Cables

Circuit Integrity (CI) cables, specified in 725.179(A), (B), (C), and (E), and used for survivability of critical circuits, shall have the additional classification using the suffix "CI" Circuit integrity (CI) cables shall only be permitted to be installed in a raceway where specifically listed and marked as part of an electrical circuit protective system as covered in 725.179(F)(2).

(2) Electrical Circuit Protective System

Cables specified in 725.179(A), (B), (C), (E), and (F)(1) that are part of an electrical circuit protective system shall be identified with the protective system number and hourly rating printed on the outer jacket of the cable and installed in accordance with the listing of the protective system.

Informational Note No. 1: One method of defining circuit integrity (CI) cable or an electrical circuit protective system is by establishing a minimum 2-hour fire-resistive rating when tested in accordance with ANSI/UL 2196-2017, Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control and Data Cables.

Informational Note No. 2: UL guide information for electrical circuit protective systems (FHIT) contains information on proper installation requirements to maintain the fire rating.

(G) Class 2 and Class 3 Cable Voltage and Temperature Ratings

Class 2 cables shall have a voltage rating of not less than 150 volts. Class 3 cables shall have a voltage rating of not less than 300 volts. Class 2 and Class 3 cables shall have a temperature rating of not less than 60°C (140°F).

(H) Class 3 Single Conductors

Class 3 single conductors used as other wiring within buildings shall not be smaller than 18 AWG and shall be Type CL3. Conductor types described in 725.49(B) that are also listed as Type CL3 shall be permitted.

Informational Note: One method of defining resistant to the spread of fire is that the cables do not spread fire to the top of the tray in the UL flame exposure, vertical tray flame test in ANSI/UL 1685-2010, Standard for Safety for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables. The smoke measurements in the test method are not applicable.

Another method of defining resistant to the spread of fire is for the damage (char length) not to exceed 1.5 m (4 ft 11 in.) when performing the CSA vertical tray flame test for cables in cable trays, as described in CSA C22.2 No. 0.3-M-2001, Test Methods for Electrical Wires and Cables.

(I) Limited Power (LP) Cables

Limited power (LP) cables shall be listed as suitable for carrying power and data up to a specified current limit for each conductor without exceeding the temperature rating of the cable where the cable is installed in cable bundles in free air or installed within a raceway, cable tray, or cable routing assembly. The cables shall be marked with the suffix "LP (XXA)" where XXA designates the current limit is in amperes per conductor.

Informational Note: An example of the marking on a Class 2 cable with an LP rating is "CL2-LP (75°C) 23 AWG 4-pair," which indicates that it is a 4-pair plenum cable with 23 AWG conductors, a temperature rating of 75°C, and a current limit of 0.6 amperes per conductor (0.6 A).

(J) Marking

Cables shall be marked in accordance with 310.8(A)(2), (A)(3), (A)(4), (A)(5), and Table 725.179(J). Voltage ratings shall not be marked on the cables.

Informational Note: Voltage markings on cables may be misinterpreted to suggest that the cables may be suitable for Class 1 electric light and power applications.

Exception: Voltage markings shall be permitted where the cable has multiple listings and a voltage marking is required for one or more of the listings.

The temperature rating shall be marked on the jacket of Class 2 and Class 3 cables that have a temperature rating exceeding 60°C (140°F).

Informational Note: Class 2 and Class 3 cable types are listed in descending order of fire performance, and Class 3 cables are listed above Class 2 cables because Class 3 cables can substitute for Class 2 cables.

Table 725.179(J) Cable Marking

Cable Marking Type

CL3P Class 3 plenum cable

CL2P Class 2 plenum cable

CL3R Class 3 riser cable

CL2R Class 2 riser cable

PLTC Power-limited tray cable

CL3 Class 3 cable

CL2 Class 2 cable

CL3X Class 3 cable, limited use

CL2X Class 2 cable, limited use

(K) Optional Markings

Cables shall be permitted to be surface marked to indicate special characteristics of the cable materials.

Informational Note No. 1: These markings include, but are not limited to, markings for limited smoke, halogen free, low smoke and halogen free, and sunlight resistant.

Informational Note No. 2: Some examples of optional markings are STI to indicate limited smoke characteristics in accordance with UL 2556, Wire and Cable Test Methods; HF to indicate halogen free as described in UL 2885, Outline of Investigation for Acid Gas, Acidity and Conductivity of Combusted Materials; and LSHF to indicate halogen free and low smoke characteristics in accordance with IEC 61034-2, Measurement of smoke density of cables burning under defined conditions — Part 2: Test procedure and requirements.

Article 727 Instrumentation Tray Cable: Type ITC

727.1 Scope

This article covers the use, installation, and construction specifications of instrumentation tray cable for application to instrumentation and control circuits operating at 150 volts or less and 5 amperes or less.

727.2 Definition

The definition in this section shall apply within this article and throughout the Code.

Type ITC Instrumentation Tray Cable. A factory assembly of two or more insulated conductors, with or without an equipment grounding conductor(s), enclosed in a nonmetallic sheath.

727.3 Other Articles

In addition to the provisions of this article, installation of Type ITC cable shall comply with other applicable articles of this Code.

727.4 Uses Permitted

Type ITC cable shall be permitted to be used as follows in industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons service the installation:

In cable trays.

In raceways.

In hazardous locations as permitted in 501.10, 502.10, 503.10, 504.20, 504.30, 504.80, and 505.15.

Enclosed in a smooth metallic sheath, continuous corrugated metallic sheath, or interlocking tape armor applied over the nonmetallic sheath in accordance with 727.6. The cable shall be supported and secured at intervals not exceeding 1.8 m (6 ft).

Cable, without a metallic sheath or armor, that complies with the crush and impact requirements of Type MC cable and is identified for such use with the marking ITC-ER shall be permitted to be installed exposed. The cable shall be continuously supported and protected against physical damage using mechanical protection such as dedicated struts, angles, or channels. The cable shall be secured at intervals not exceeding 1.8 m (6 ft).

Exception to (5): Where not subject to physical damage, Type ITC-ER shall be permitted to transition between cable trays and between cable trays and utilization equipment or devices for a distance not to exceed 1.8 m (6 ft) without continuous support. The cable shall be mechanically supported where exiting the cable tray to ensure that the minimum bending radius is not exceeded.

As aerial cable on a messenger.

Direct buried where identified for the use.

Under raised floors in rooms containing industrial process control equipment and rack rooms where arranged to prevent damage to the cable.

Under raised floors in information technology equipment rooms in accordance with 645.5(E)(2).

727.5 Uses Not Permitted

Type ITC cable shall not be installed on circuits operating at more than 150 volts or more than 5 amperes.

Installation of Type ITC cable with other cables shall be subject to the stated provisions of the specific articles for the other cables. Where the governing articles do not contain stated provisions for installation with Type ITC cable, the installation of Type ITC cable with the other cables shall not be permitted.

Type ITC cable shall not be installed with power, lighting, Class 1 circuits that are not power limited, or non—power-limited circuits.

Exception No. 1: Where terminated within equipment or junction boxes and separations are maintained by insulating barriers or other means.

Exception No. 2: Where a metallic sheath or armor is applied over the nonmetallic sheath of the Type ITC cable.

727.6 Construction

The insulated conductors of Type ITC cable shall be in sizes 22 AWG through 12 AWG. The conductor material shall be copper or thermocouple alloy. Insulation on the conductors shall be rated for 300 volts. Shielding shall be permitted.

The cable shall be listed as being resistant to the spread of fire. The outer jacket shall be sunlight and moisture resistant.

Where a smooth metallic sheath, continuous corrugated metallic sheath, or interlocking tape armor is applied over the nonmetallic sheath, an overall nonmetallic jacket shall not be required.

Informational Note: One method of defining resistant to the spread of fire is that the cables do not spread fire to the top of the tray in the UL flame exposure, vertical tray flame test in ANSI/UL 1685-2010, Standard for Safety for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables. The smoke measurements in the test method are not applicable.

Another method of defining resistant to the spread of fire is for the damage (char length) not to exceed 1.5 m (4 ft 11 in.) when performing the CSA vertical flame test — cables in cable trays, as described in CSA C22.2 No. 0.3-M-2001, Test Methods for Electrical Wires and Cables.

727.7 Marking

The cable shall be marked in accordance with 310.8(A)(2), (A)(3), (A)(4), and (A)(5). Voltage ratings shall not be marked on the cable.

727.8 Ampacity

The ampacity of the conductors shall be 5 amperes, except for 22 AWG conductors, which shall have an ampacity of 3 amperes.

727.9 Overcurrent Protection

Overcurrent protection shall not exceed 5 amperes for 20 AWG and larger conductors, and 3 amperes for 22 AWG conductors.

727.10 Bends

Bends in Type ITC cables shall be made so as not to damage the cable.

Article 728 Fire-Resistive Cable Systems

728.1 Scope

This article covers the installation of fire-resistive cables, fire-resistive conductors, and other system components used for survivability of critical circuits to ensure continued operation during a specified time under fire conditions as required in this Code.

728.2 Definition

The definition in this section shall apply within this article and throughout the Code.

Fire-Resistive Cable System. A cable and components used to ensure survivability of critical circuits for a specified time under fire conditions.

728.3 Other Articles

Wherever the requirements of other articles of this Code and Article 728 differ, the requirements of Article 728 shall apply.

728.4 General

Fire-resistive cables, fire-resistive conductors, and components shall be tested and listed as a complete system, shall be designated for use in a specific fire-rated system, and shall not be interchangeable between systems.

Informational Note No. 1: One method of defining the fire rating is by testing the system in accordance with ANSI/UL 2196-2017, Standard for Fire Test for Circuit Integrity of Fire - Resistive Power, Instrumentation, Control and Data Cables.

Informational Note No. 2: Fire-resistive cable systems are considered part of an electrical circuit protective system.

728.5 Installations

Fire-resistive cable systems installed outside the fire-rated rooms that they serve, such as the electrical room or the fire pump room, shall comply with the requirements of 728.5(A) through (H) and all other installation instructions provided in the listing.

(A) Mounting

The fire-resistive cable system shall be secured to the building structure in accordance with the listing and the manufacturer's installation instructions.

(B) Supports

The fire-resistive system shall be supported in accordance with the listing and the manufacturer's installation instructions.

Informational Note: The supports are critical for survivability of the system. Each system has its specific support requirements.

(C) Raceways and Couplings

Where the fire-resistive system is listed to be installed in a raceway, the raceways enclosing the system, any couplings, and connectors shall be listed as part of the fire-rated system.

The raceway fill for each system shall comply with the listing requirements for the system and shall not be greater than the fill permitted in Table 1, Chapter 9.

Informational Note: Raceway fill may not be the same for all listed fire-resistive systems.

(D) Cable Trays

Cable trays used as part of a fire-resistive system shall be listed as part of the fire-resistive system.

(E) Boxes

Boxes or enclosures used as part of a fire-resistive system shall be listed as part of the fire-resistive system and shall be secured to the building structure independently of the raceways or cables listed in the system.

(F) Pulling Lubricants

Fire-resistive cable systems installed in a raceway shall only use pulling lubricants listed as part of the fire-resistive cable system.

(G) Vertical Supports

Cables and conductors installed in vertical raceways shall be supported in accordance with the listing of the fire-resistive cable system.

(H) Splices

Only splices that are part of the listing for the fire-resistive cable system shall be used. Splices shall have manufacturer's installation instructions.

728.60 Equipment Grounding Conductor

Fire-resistive systems installed in a raceway requiring an equipment grounding conductor shall use the same fire-rated cable described in the system, unless alternative equipment grounding conductors are listed with the system. Any alternative equipment grounding conductor shall be marked with the system number. The system shall specify a permissible equipment grounding conductor. If not specified, the equipment grounding conductor shall be the same as the fire-rated cable described in the system.

728.120 Marking

In addition to the marking required in 310.8, system cables and conductors shall be surface marked with the suffix "FRR" (fire-resistive rating), along with the circuit integrity duration in hours, and with the system identifier.

Article 750 Energy Management Systems

750.1 Scope

This article applies to the installation and operation of energy management systems.

Informational Note: Performance provisions in other codes establish prescriptive requirements that may further restrict the requirements contained in this article.

750.2 Definitions

Control. This definition shall apply only within this article.

The predetermined process of connecting, disconnecting, increasing, or reducing electric power.

Energy Management System. This definition shall apply within this article and throughout the Code.

A system consisting of any of the following: a monitor(s), communications equipment, a controller(s), a timer(s), or other device(s) that monitors and/or controls an electrical load or a power production or storage source.

Monitor. This definition shall apply only within this article.

An electrical or electronic means to observe, record, or detect the operation or condition of the electric power system or apparatus.

750.20 Alternate Power Sources

An energy management system shall not override any control necessary to ensure continuity of an alternate power source for the following:

Fire pumps

Health care facilities

Emergency systems

Legally required standby systems

Critical operations power systems

750.30 Load Management

Energy management systems shall be permitted to monitor and control electrical loads unless restricted in accordance with 750.30(A) through (C).

(A) Load Shedding Controls

An energy management system shall not override the load shedding controls put in place to ensure the minimum electrical capacity for the following:

Fire pumps

Emergency systems

Legally required standby systems

Critical operations power systems

(B) Disconnection of Power

An energy management system shall not be permitted to cause disconnection of power to the following:

Elevators, escalators, moving walks, or stairway lift chairs

Positive mechanical ventilation for hazardous (classified) locations

Ventilation used to exhaust hazardous gas or reclassify an area

Circuits supplying emergency lighting

Essential electrical systems in health care facilities

(C) Capacity of Branch Circuit, Feeder, or Service

An energy management system shall not cause a branch circuit, feeder, or service to be overloaded at any time.

750.50 Field Markings

Where an energy management system is employed to control electrical power through the use of a remote means, a directory identifying the controlled device(s) and circuit(s) shall be posted on the enclosure of the controller, disconnect, or branch-circuit overcurrent device.

Informational Note: The use of the term remote is intended to convey that a controller can be operated via another means or location through communications without a direct operator interface with the controlled device.

Article 760 Fire Alarm Systems

Part I General

760.1 Scope

This article covers the installation of wiring and equipment of fire alarm systems, including all circuits controlled and powered by the fire alarm system.

Informational Note No. 1: Fire alarm systems include fire detection and alarm notification, guard's tour, sprinkler waterflow, and sprinkler supervisory systems. Circuits controlled and powered by the fire alarm system include circuits for the control of building systems safety functions, elevator capture, elevator shutdown, door release, smoke doors and damper control, fire doors and damper control and fan shutdown, but only where these circuits are powered by and controlled by the fire alarm system. For further information on the installation and monitoring for integrity requirements for fire alarm systems, refer to the NFPA 72-2019, National Fire Alarm and Signaling Code.

Informational Note No. 2: Class 1, 2, and 3 circuits are defined in Article 725.

760.2 Definitions

The definitions in this section shall apply only within this article.

Abandoned Fire Alarm Cable. Installed fire alarm cable that is not terminated at equipment other than a connector and not identified for future use with a tag.

Fire Alarm Circuit. The portion of the wiring system between the load side of the overcurrent device or the power-limited supply and the connected equipment of all circuits powered and controlled by the fire alarm system. Fire alarm circuits are classified as either non-power-limited or power-limited.

Fire Alarm Circuit Integrity (CI) Cable. Cable used in fire alarm systems to ensure continued operation of critical circuits during a specified time under fire conditions.

Non—Power-Limited Fire Alarm Circuit (NPLFA). A fire alarm circuit powered by a source that complies with 760.41 and 760.43.

Power-Limited Fire Alarm Circuit (PLFA). A fire alarm circuit powered by a source that complies with 760.121.

760.3 Other Articles

Circuits and equipment shall comply with 760.3(A) through (O). Only those sections of Article 300 referenced in this article shall apply to fire alarm systems.

(A) Spread of Fire or Products of Combustion

See 300.21.

(B) Ducts, Plenums, and Other Air-Handling Spaces

Power-limited and non-power-limited fire alarm cables installed in ducts, plenums, or other spaces used for environmental air shall comply with 300.22.

Exception No. 1: Power-limited fire alarm cables selected in accordance with Table 760.154 and installed in accordance with 760.135(B) and 300.22(B), Exception shall be permitted to be installed in ducts specifically fabricated for environmental air.

Exception No. 2: Power-limited fire alarm cables selected in accordance with Table 760.154 and installed in accordance with 760.135(C) shall be permitted to be installed in other spaces used for environmental air (plenums).

(C) Hazardous (Classified) Locations

Articles 500 through 516 and Article 517, Part IV, where installed in hazardous (classified) locations.

(D) Corrosive, Damp, or Wet Locations

Sections 110.11, 300.5(B), 300.6, 300.9, and 310.10(F), where installed in corrosive, damp, or wet locations.

(E) Building Control Circuits

Article 725, where building control circuits (e.g., elevator capture, fan shutdown) are associated with the fire alarm system.

(F) Optical Fiber Cables

Where optical fiber cables are utilized for fire alarm circuits, the cables shall be installed in accordance with Article 770.

(G) Installation of Conductors With Other Systems

Installations shall comply with 300.8.

(H) Raceways or Sleeves Exposed to Different Temperatures

Installations shall comply with 300.7(A).

(I) Vertical Support for Fire Rated Cables and Conductors

Vertical installations of circuit integrity (CI) cables and conductors installed in a raceway or conductors and cables of electrical circuit protective systems shall be installed in accordance with 300.19.

(J) Number and Size of Cables and Conductors in Raceway

Installations shall comply with 300.17.

(K) Bushing

A bushing shall be installed where cables emerge from raceway used for mechanical support or protection in accordance with 300.15(C).

(L) Cable Routing Assemblies

Power-limited fire alarm cables shall be permitted to be installed in plenum cable routing assemblies, riser cable routing assemblies, and general-purpose cable routing assemblies selected in accordance with Table 800.154(c), listed in accordance with 800.182, and installed in accordance with 800.110(C) and 800.113.

(M) Communications Raceways

Power-limited fire alarm cables shall be permitted to be installed in plenum communications raceways, riser communications raceways, and general-purpose communications raceways selected in accordance with Table 800.154(b), listed in accordance with 800.182, and installed in accordance with 800.113 and 362.24 through 362.56, where the requirements applicable to electrical nonmetallic tubing apply.

(N) Temperature Limitations of Power-Limited and Non—Power-Limited Fire Alarm Cables

The requirements of 310.14(A)(3) on the temperature limitation of conductors shall apply to power-limited fire alarm cables and non—power-limited fire alarms cables.

(O) Identification of Equipment Grounding Conductors

Equipment grounding conductors shall be identified in accordance with 250.119.

Exception: Conductors with green insulation shall be permitted to be used as ungrounded signal conductors for Types FPLP, FPLR, FPL, and substitute cables installed in accordance with 760.154(A).

760.21 Access to Electrical Equipment Behind Panels Designed to Allow Access

Access to electrical equipment shall not be denied by an accumulation of conductors and cables that prevents removal of panels, including suspended ceiling panels.

760.24 Mechanical Execution of Work

(A) General

Fire alarm circuits shall be installed in a neat workmanlike manner. Cables and conductors installed exposed on the surface of ceilings and sidewalls shall be supported by the building structure in such a manner that the cable will not be damaged by normal building use. Such cables shall be supported by straps, staples, cable ties, hangers, or similar fittings designed and installed so as not to damage the cable. The installation shall also comply with 300.4.

Informational Note: Paint, plaster, cleaners, abrasives, corrosive residues, or other contaminants might result in an undetermined alteration of PLFA and NPLFA cable properties.

(B) Circuit Integrity (CI) Cable

Circuit integrity (CI) cables shall be supported at a distance not exceeding 610 mm (24 in.). Where located within 2.1 m (7 ft) of the floor, as covered in 760.53(A)(1) and 760.130(B)(1), as applicable, the cable shall be fastened in an approved manner at intervals of not more than 450 mm (18 in.). Cable supports and fasteners shall be steel.

760.25 Abandoned Cables

The accessible portion of abandoned fire alarm cables shall be removed. Where cables are identified for future use with a tag, the tag shall be of sufficient durability to withstand the environment involved.

760.30 Fire Alarm Circuit Identification

Fire alarm circuits shall be identified at terminal and junction locations in a manner that helps to prevent unintentional signals on fire alarm system circuit(s) during testing and servicing of other systems.

760.32 Fire Alarm Circuits Extending Beyond One Building

Non-power-limited fire alarm circuits and power-limited fire alarm circuits that extend beyond one building and run outdoors shall meet the installation requirements of Parts II, III, and IV of Article 805 and shall meet the installation requirements of Part I of Article 300.

Informational Note: An example of a protective device suitable to provide protection is a device tested to the requirements of ANSI/UL 497B, Protectors for Data Communications.

760.35 Fire Alarm Circuit Requirements

Fire alarm circuits shall comply with 760.35(A) and (B).

(A) Non-Power-Limited Fire Alarm (NPLFA) Circuits

See Parts I and II.

(B) Power-Limited Fire Alarm (PLFA) Circuits

See Parts I and III.

Part II Non-Power-Limited Fire Alarm (NPLFA) Circuits

760.41 NPLFA Circuit Power Source Requirements

(A) Power Source

The power source of non-power-limited fire alarm circuits shall comply with Chapters 1 through 4, and the output voltage shall be not more than 600 volts, nominal. The fire alarm circuit disconnect shall be permitted to be secured in the "on" position.

(B) Branch Circuit

The branch circuit supplying the fire alarm equipment(s) shall supply no other loads. The location of the branch-circuit overcurrent protective device shall be permanently identified at the fire alarm control unit. The circuit disconnecting means shall have red identification, shall be accessible only to qualified personnel, and shall be identified as "FIRE ALARM CIRCUIT." The red identification shall not damage the overcurrent protective devices or obscure the manufacturer's markings. This branch circuit shall not be supplied through ground-fault circuit interrupters or arc-fault circuit-interrupters.

Informational Note: See 210.8(A)(5), Exception, for receptacles in dwelling-unit unfinished basements that supply power for fire alarm systems.

760.43 NPLFA Circuit Overcurrent Protection

Overcurrent protection for conductors 14 AWG and larger shall be provided in accordance with the conductor ampacity without applying the ampacity adjustment and correction factors of 310.14 to the ampacity calculation. Overcurrent protection shall not exceed 7 amperes for 18 AWG conductors and 10 amperes for 16 AWG conductors.

Exception: Where other articles of this Code permit or require other overcurrent protection.

760.45 NPLFA Circuit Overcurrent Device Location

Overcurrent devices shall be located at the point where the conductor to be protected receives its supply.

Exception No. 1: Where the overcurrent device protecting the larger conductor also protects the smaller conductor.

Exception No. 2: Transformer secondary conductors. Non—power-limited fire alarm circuit conductors supplied by the secondary of a single-phase transformer that has only a 2-wire (single-voltage) secondary shall be permitted to be protected by overcurrent protection provided by the primary (supply) side of the transformer, provided the protection is in accordance with 450.3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio. Transformer secondary conductors other than 2-wire shall not be considered to be protected by the primary overcurrent protection.

Exception No. 3: Electronic power source output conductors. Non—power-limited circuit conductors supplied by the output of a single-phase, listed electronic power source, other than a transformer, having only a 2-wire (single-voltage) output for connection to non—power-limited circuits shall be permitted to be protected by overcurrent protection provided on the input side of the electronic power source, provided this protection does not exceed the value determined by multiplying the non-power-limited circuit conductor ampacity by the output-to-input voltage ratio. Electronic power source outputs, other than 2-wire (single voltage), connected to non-power-limited circuits shall not be considered to be protected by overcurrent protection on the input of the electronic power source.

Informational Note: A single-phase, listed electronic power supply whose output supplies a 2-wire (single-voltage) circuit is an example of a non-power-limited power source that meets the requirements of 760.41.

760.46 NPLFA Circuit Wiring

Installation of non-power-limited fire alarm circuits shall be in accordance with 110.3(B), 300.7, 300.11, 300.15, 300.17, 300.19(B), and other appropriate articles of Chapter 3.

Exception No. 1: As provided in 760.48 through 760.53.

Exception No. 2: Where other articles of this Code require other methods.

760.48 Conductors of Different Circuits in Same Cable, Enclosure, or Raceway

(A) Class 1 With NPLFA Circuits

Class 1 and non-power-limited fire alarm circuits shall be permitted to occupy the same cable, enclosure, or raceway without regard to whether the individual circuits are alternating current or direct current, provided all conductors are insulated for the maximum voltage of any conductor in the enclosure or raceway.

(B) Fire Alarm With Power-Supply Circuits

Power-supply and fire alarm circuit conductors shall be permitted in the same cable, enclosure, or raceway only where connected to the same equipment.

760.49 NPLFA Circuit Conductors

(A) Sizes and Use

Only copper conductors shall be permitted to be used for fire alarm systems. Size 18 AWG and 16 AWG conductors shall be permitted to be used, provided they supply loads that do not exceed the ampacities given in Table 402.5 and are installed in a raceway, an approved enclosure, or a listed cable. Conductors larger than 16 AWG shall not supply loads greater than the ampacities given in 310.14, as applicable.

(B) Insulation

Insulation on conductors shall be rated for the system voltage and not less than 600 volts. Conductors larger than 16 AWG shall comply with Article 310. Conductors 18 AWG and 16 AWG shall be Type KF-2, KFF-2, PAFF, PTFF, PF, PFF, PGF, PGFF, RFH-2, RFHH-2, RFHH-3, SF-2, SFF-2, TF, TFF, TFN, TFFN, ZF, or ZFF. Conductors with other types and thickness of insulation shall be permitted if listed for non-power-limited fire alarm circuit use.

Informational Note: For application provisions, see Table 402.3.

(C) Conductor Materials

Conductors shall be solid or stranded copper.

Exception to (B) and (C): Wire Types PAF and PTF shall be permitted only for high-temperature applications between 90°C (194°F) and 250°C (482°F).

760.51 Number of Conductors in Cable Trays and Raceways, and Ampacity Adjustment Factors

(A) NPLFA Circuits and Class 1 Circuits

Where only nonpower-limited fire alarm circuit and Class 1 circuit conductors are in a raceway, the number of conductors shall be determined in accordance with 300.17. The ampacity adjustment factors given in 310.15(C)(1) shall apply if such conductors carry continuous load in excess of 10 percent of the ampacity of each conductor.

(B) Power-Supply Conductors and NPLFA Circuit Conductors

Where power-supply conductors and non-power-limited fire alarm circuit conductors are permitted in a raceway in accordance with 760.48, the number of conductors shall be determined in accordance with 300.17. The ampacity adjustment factors given in 310.15(C)(1) shall apply as follows:

To all conductors where the fire alarm circuit conductors carry continuous loads in excess of 10 percent of the ampacity of each conductor and where the total number of conductors is more than three

To the power-supply conductors only, where the fire alarm circuit conductors do not carry continuous loads in excess of 10 percent of the ampacity of each conductor and where the number of power-supply conductors is more than three

(C) Cable Trays

Where fire alarm circuit conductors are installed in cable trays, they shall comply with 392.22 and 392.80(A).

760.53 Multiconductor NPLFA Cables

Multiconductor non-power-limited fire alarm cables that meet the requirements of 760.176 shall be permitted to be used on fire alarm circuits operating at 150 volts or less and shall be installed in accordance with 760.53(A) and (B).

(A) NPLFA Wiring Method

Multiconductor non-power-limited fire alarm circuit cables shall be installed in accordance with 760.53(A)(1), (A)(2), and (A)(3).

(1) In Raceways, Exposed on Ceilings or Sidewalls, or Fished in Concealed Spaces

Cable splices or terminations shall be made in listed fittings, boxes, enclosures, fire alarm devices, or utilization equipment. Where installed exposed, cables shall be adequately supported and installed in such a way that maximum protection against physical damage is afforded by building construction such as baseboards, door frames, ledges, and so forth. Where located within 2.1 m (7 ft) of the floor, cables shall be securely fastened in an approved manner at intervals of not more than 450 mm (18 in.).

(2) Passing Through a Floor or Wall

Cables shall be installed in metal raceway or rigid nonmetallic conduit where passing through a floor or wall to a height of 2.1 m (7 ft) above the floor, unless adequate protection can be afforded by building construction such as detailed in 760.53(A)(1), or unless an equivalent solid guard is provided.

(3) In Hoistways

Cables shall be installed in rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible nonmetallic conduit, or electrical metallic tubing where installed in hoistways.

Exception: As provided for in 620.21 for elevators and similar equipment.

(B) Applications of Listed NPLFA Cables

The use of non-power-limited fire alarm circuit cables shall comply with 760.53(B)(1) through (B)(4).

(1) Ducts Specifically Fabricated for Environmental Air

Multiconductor non—power-limited fire alarm circuit cables, Types NPLFP, NPLFR, and NPLF, shall not be installed exposed in ducts specifically fabricated for environmental air.

Informational Note: See 300.22(B).

(2) Other Spaces Used for Environmental Air (Plenums)

Cables installed in other spaces used for environmental air shall be Type NPLFP.

Exception No. 1: Types NPLFR and NPLF cables installed in compliance with 300.22(C).

Exception No. 2: Other wiring methods in accordance with 300.22(C) and conductors in compliance with 760.49(C).

Exception No. 3: Type NPLFP-CI cable shall be permitted to be installed to provide a 2-hour circuit integrity rated cable.

(3) Riser

Cables installed in vertical runs and penetrating one or more floors, or cables installed in vertical runs in a shaft, shall be Type NPLFR. Floor penetrations requiring Type NPLFR shall contain only cables suitable for riser or plenum use.

Exception No. 1: Type NPLF or other cables that are specified in Chapter 3 and are in compliance with 760.49(C) and encased in metal raceway.

Exception No. 2: Type NPLF cables located in a fireproof shaft having firestops at each floor.

Informational Note: See 300.21 for firestop requirements for floor penetrations.

Exception No. 3: Type NPLF-CI cable shall be permitted to be installed to provide a 2-hour circuit integrity rated cable.

(4) Other Wiring Within Buildings

Cables installed in building locations other than the locations covered in 760.53(B)(1), (B)(2), and (B)(3) shall be Type NPLF.

Exception No. 1: Chapter 3 wiring methods with conductors in compliance with 760.49(C).

Exception No. 2: Type NPLFP or Type NPLFR cables shall be permitted.

Exception No. 3: Type NPLFR-CI cable shall be permitted to be installed to provide a 2-hour circuit integrity rated cable.

Part III Power-Limited Fire Alarm (PLFA) Circuits

760.121 Power Sources for PLFA Circuits

(A) Power Source

The power source for a power-limited fire alarm circuit shall be as specified in the following:

Informational Note No. 1: Tables 12(A) and 12(B) in Chapter 9 provide the listing requirements for power-limited fire alarm circuit sources.

Informational Note No. 2: See 210.8(A)(5), Exception, for receptacles in dwelling-unit unfinished basements that supply power for fire alarm systems.

A listed PLFA or Class 3 transformer

A listed PLFA or Class 3 power supply

Listed equipment marked to identify the PLFA power source

Informational Note: Examples of listed equipment are a fire alarm control panel with integral power source; a circuit card listed for use as a PLFA source, where used as part of a listed assembly; a current-limiting impedance, listed for the purpose or part of a listed product, used in conjunction with a non-power-limited transformer or a stored energy source, for example, storage battery, to limit the output current.

(B) Branch Circuit

The branch circuit supplying the fire alarm equipment(s) shall supply no other loads. The location of the branch-circuit overcurrent protective device shall be permanently identified at the fire alarm control unit. The circuit disconnecting means shall have red identification, shall be accessible only to qualified personnel, and shall be identified as "FIRE ALARM CIRCUIT." The red identification shall not damage the overcurrent protective devices or obscure the manufacturer's markings. This branch circuit shall not be supplied through ground-fault circuit interrupters or arc-fault circuit interrupters. The fire alarm branch-circuit disconnecting means shall be permitted to be secured in the "on" position.

760.124 Circuit Marking

The equipment supplying PLFA circuits shall be durably marked where plainly visible to indicate each circuit that is a power-limited fire alarm circuit.

Informational Note: See 760.130(A), Exception No. 3, where a power-limited circuit is to be reclassified as a non-power-limited circuit.

760.127 Wiring Methods on Supply Side of the PLFA Power Source

Conductors and equipment on the supply side of the power source shall be installed in accordance with the appropriate requirements of Part II and Chapters 1 through 4. Transformers or other devices supplied from power-supply conductors shall be protected by an overcurrent device rated not over 20 amperes.

Exception: The input leads of a transformer or other power source supplying power-limited fire alarm circuits shall be permitted to be smaller than 14 AWG, but not smaller than 18 AWG, if they are not over 300 mm (12 in.) long and if they have insulation that complies with 760.49(B).

760.130 Wiring Methods and Materials on Load Side of the PLFA Power Source

Fire alarm circuits on the load side of the power source shall be permitted to be installed using wiring methods and materials in accordance with 760.130(A), (B), or a combination of (A) and (B).

(A) NPLFA Wiring Methods and Materials

Installation shall be in accordance with 760.46, and conductors shall be solid or stranded copper.

Exception No. 1: The ampacity adjustment factors given in 310.15(C)(1) shall not apply.

Exception No. 2: Conductors and multiconductor cables described in and installed in accordance with 760.49 and 760.53 shall be permitted.

Exception No. 3: Power-limited circuits shall be permitted to be reclassified and installed as non—power-limited circuits if the power-limited fire alarm circuit markings required by 760.124 are eliminated and the entire circuit is installed using the wiring methods and materials in accordance with Part II, Non-Power-Limited Fire Alarm Circuits.

Informational Note: Power-limited circuits reclassified and installed as non-power-limited circuits are no longer power-limited circuits, regardless of the continued connection to a power-limited source.

(B) PLFA Wiring Methods and Materials

Power-limited fire alarm conductors and cables described in 760.179 shall be installed as detailed in 760.130(B)(1), (B)(2), or (B)(3) of this section and 300.7. Devices shall be installed in accordance with 110.3(B), 300.11(A), and 300.15.

(1) In Raceways, Exposed on Ceilings or Sidewalls, or Fished in Concealed Spaces

Cable splices or terminations shall be made in listed fittings, boxes, enclosures, fire alarm devices, or utilization equipment. Where installed exposed, cables shall be adequately supported and installed in such a way that maximum protection against physical damage is afforded by building construction such as baseboards, door frames, ledges, and so forth. Where located within 2.1 m (7 ft) of the floor, cables shall be securely fastened in an approved manner at intervals of not more than 450 mm (18 in.).

(2) Passing Through a Floor or Wall

Cables shall be installed in metal raceways or rigid nonmetallic conduit where passing through a floor or wall to a height of 2.1 m (7 ft) above the floor, unless adequate protection can be afforded by building construction such as detailed in 760.130(B)(1), or unless an equivalent solid guard is provided.

(3) In Hoistways

Cables shall be installed in rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, or electrical metallic tubing where installed in hoistways.

Exception: As provided for in 620.21 for elevators and similar equipment.

760.133 Installation of Conductors and Equipment in Cables, Compartments, Cable Trays, Enclosures, Manholes, Outlet Boxes, Device Boxes, Raceways, and Cable Routing Assemblies for Power-Limited Fire Alarm Circuits

Conductors and equipment for power-limited fire alarm circuits shall be installed in accordance with 760.135 through 760.143.

760.135 Installation of PLFA Cables in Buildings

Installation of power-limited fire alarm cables in buildings shall comply with 760.135(A) through (J).

(A) Listing

PLFA cables installed in buildings shall be listed.

(B) Ducts Specifically Fabricated for Environmental Air

The following cables shall be permitted in ducts specifically fabricated for environmental air as described in 300.22(B), if they are directly associated with the air distribution system:

Types FPLP and FPLP-CI cables in lengths as short as practicable to perform the required function

Types FPLP, FPLP-CI, FPLR, FPLR-CI, FPL, and FPL-CI cables installed in raceways that are installed in compliance with 300.22(B)

Informational Note: For information on fire protection of wiring installed in fabricated ducts, see 4.3.4.1 and 4.3.11.3.3 of NFPA 90A-2018, Standard for the Installation of Air-Conditioning and Ventilating Systems.

(C) Other Spaces Used for Environmental Air (Plenums)

The following cables shall be permitted in other spaces used for environmental air as described in 300.22(C):

Type FPLP cables

Type FPLP cables installed in plenum communications raceways

Type FPLP cables installed in plenum routing assemblies

Types FPLP and FPLP-CI cables supported by open metallic cable trays or cable tray systems

Types FPLP, FPLR, and FPL cables installed in raceways that are installed in compliance with 300.22(C)

Types FPLP, FPLR, and FPL cables supported by solid bottom metal cable trays with solid metal covers in other spaces used for environmental air (plenums) as described in 300.22(C)

Types FPLP, FPLR, and FPL cables installed in plenum communications raceways, riser communications raceways, or general-purpose communications raceways supported by solid bottom metal cable trays with solid metal covers in other spaces used for environmental air (plenums) as described in 300.22(C)

(D) Risers — Cables in Vertical Runs

The following cables shall be permitted in vertical runs penetrating one or more floors and in vertical runs in a shaft:

Types FPLP and FPLR cables

Types FPLP and FPLR cables installed in the following:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

Informational Note: See 300.21 for firestop requirements for floor penetrations.

(E) Risers — Cables in Metal Raceways

The following cables shall be permitted in metal raceways in a riser having firestops at each floor:

Types FPLP, FPLR, and FPL cables

Types FPLP, FPLR, and FPL cables installed in the following:

Plenum communications raceways

Riser communications raceways

General-purpose communications raceways

Informational Note: See 300.21 for firestop requirements for floor penetrations.

(F) Risers — Cables in Fireproof Shafts

The following cables shall be permitted to be installed in fireproof riser shafts having firestops at each floor:

Types FPLP, FPLR, and FPL cables

Types FPLP, FPLR, and FPL cables installed in the following:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

Informational Note: See 300.21 for firestop requirements for floor penetrations.

(G) Risers — One- And Two-Family Dwellings

The following cables shall be permitted in one- and two-family dwellings:

Types FPLP, FPLR, and FPL cables

Types FPLP, FPLR, and FPL cables installed in the following:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

(H) Other Building Locations

The following cables shall be permitted to be installed in building locations other than the locations covered in 770.113(B) through (H):

Types FPLP, FPLR, and FPL cables

Types FPLP, FPLR, and FPL cables installed in the following:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

Types FPLP, FPLR, and FPL cables installed in a raceway of a type recognized in Chapter 3

(I) Nonconcealed Spaces

Cables specified in Chapter 3 and meeting the requirements of 760.179(A) and (B) shall be permitted to be installed in nonconcealed spaces where the exposed length of cable does not exceed 3 m (10 ft).

(J) Portable Fire Alarm System

A portable fire alarm system provided to protect a stage or set when not in use shall be permitted to use wiring methods in accordance with 530.12.

760.136 Separation From Electric Light, Power, Class 1, NPLFA, and Medium-Power Network-Powered Broadband Communications Circuit Conductors

(A) General

Power-limited fire alarm circuit cables and conductors shall not be placed in any cable, cable tray, compartment, enclosure, manhole, outlet box, device box, raceway, or similar fitting with conductors of electric light, power, Class 1, non—power-limited fire alarm circuits, and medium-power network-powered broadband communications circuits unless permitted by 760.136(B) through (G).

(B) Separated by Barriers

Power-limited fire alarm circuit cables shall be permitted to be installed together with Class 1, non—power-limited fire alarm, and medium-power network-powered broadband communications circuits where they are separated by a barrier.

(C) Raceways Within Enclosures

In enclosures, power-limited fire alarm circuits shall be permitted to be installed in a raceway within the enclosure to separate them from Class 1, non-power-limited fire alarm, and medium-power network-powered broadband communications circuits.

(D) Associated Systems Within Enclosures

Power-limited fire alarm conductors in compartments, enclosures, device boxes, outlet boxes, or similar fittings shall be permitted to be installed with electric light, power, Class 1, non-power-limited fire alarm, and medium power network-powered broadband communications circuits where they are introduced solely to connect the equipment connected to power-limited fire alarm circuits, and comply with either of the following conditions:

The electric light, power, Class 1, non-power-limited fire alarm, and medium-power network-powered broadband communications circuit conductors are routed to maintain a minimum of 6 mm (0.25 in.) separation from the conductors and cables of power-limited fire alarm circuits.

The circuit conductors operate at 150 volts or less to ground and also comply with one of the following:

The fire alarm power-limited circuits are installed using Type FPL, FPLR, FPLP, or permitted substitute cables, provided these power-limited cable conductors extending beyond the jacket are separated by a minimum of 6 mm (0.25 in.) or by a nonconductive sleeve or nonconductive barrier from all other conductors.

The power-limited fire alarm circuit conductors are installed as non-power-limited circuits in accordance with 760.46.

(E) Enclosures With Single Opening

Power-limited fire alarm circuit conductors entering compartments, enclosures, device boxes, outlet boxes, or similar fittings shall be permitted to be installed with electric light, power, Class 1, non-power-limited fire alarm, and medium-power network-powered broadband communications circuits where they are introduced solely to connect the equipment connected to power-limited fire alarm circuits or to other circuits controlled by the fire alarm system to which the other conductors in the enclosure are connected. Where power-limited fire alarm circuit conductors must enter an enclosure that is provided with a single opening, they shall be permitted to enter through a single fitting (such as a tee), provided the conductors are separated from the conductors of the other circuits by a continuous and firmly fixed nonconductor, such as flexible tubing.

(F) In Hoistways

In hoistways, power-limited fire alarm circuit conductors shall be installed in rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible nonmetallic conduit, or electrical metallic tubing. For elevators or similar equipment, these conductors shall be permitted to be installed as provided in 620.21.

(G) Other Applications

For other applications, power-limited fire alarm circuit conductors shall be separated by at least 50 mm (2 in.) from conductors of any electric light, power, Class 1, non-power-limited fire alarm, or medium-power network-powered broadband communications circuits unless one of the following conditions is met:

Either (a) all of the electric light, power, Class 1, non-power-limited fire alarm, and medium-power network-powered broadband communications circuit conductors or (b) all of the power-limited fire alarm circuit conductors are in a raceway or in metal-sheathed, metal-clad, nonmetallic-sheathed, or Type UF cables.

All of the electric light, power, Class 1, non-power-limited fire alarm, and medium-power network-powered broadband communications circuit conductors are permanently separated from all of the power-limited fire alarm circuit conductors by a continuous and firmly fixed nonconductor, such as porcelain tubes or flexible tubing, in addition to the insulation on the conductors.

760.139 Installation of Conductors of Different PLFA Circuits, Class 2, Class 3, and Communications Circuits in the Same Cable, Enclosure, Cable Tray, Raceway, or Cable Routing Assembly

(A) Two or More PLFA Circuits

Cable and conductors of two or more power-limited fire alarm circuits, communications circuits, or Class 3 circuits shall be permitted within the same cable, enclosure, cable tray, raceway, or cable routing assembly.

(B) Class 2 Circuits With PLFA Circuits

Conductors of one or more Class 2 circuits shall be permitted within the same cable, enclosure, cable tray, raceway, or cable routing assembly with conductors of power-limited fire alarm circuits, provided that the insulation of the Class 2 circuit conductors in the cable, enclosure, raceway, or cable routing assembly is at least that required by the power-limited fire alarm circuits.

(C) Low-Power Network-Powered Broadband Communications Cables and PLFA Cables

Low-power network-powered broadband communications circuits shall be permitted in the same enclosure, cable tray, raceway, or cable routing assembly with PLFA cables.

(D) Audio System Circuits and PLFA Circuits

Audio system circuits described in 640.9(C) and installed using Class 2 or Class 3 wiring methods in compliance with 725.133 and 725.154 shall not be permitted to be installed in the same cable, cable tray, raceway, or cable routing assembly with power-limited conductors or cables.

760.142 Conductor Size

Conductors of 26 AWG shall be permitted only where spliced with a connector listed as suitable for 26 AWG to 24 AWG or larger conductors that are terminated on equipment or where the 26 AWG conductors are terminated on equipment listed as suitable for 26 AWG conductors. Single conductors shall not be smaller than 18 AWG.

760.143 Support of Conductors

Power-limited fire alarm circuit conductors shall not be strapped, taped, or attached by any means to the exterior of any conduit or other raceway as a means of support.

760.145 Current-Carrying Continuous Line-Type Fire Detectors

(A) Application

Listed continuous line-type fire detectors, including insulated copper tubing of pneumatically operated detectors, employed for both detection and carrying signaling currents shall be permitted to be used in power-limited circuits.

(B) Installation

Continuous line-type fire detectors shall be installed in accordance with 760.124 through 760.130 and 760.133.

760.154 Applications of Listed PLFA Cables

PLFA cables shall comply with the requirements described in Table 760.154 or where cable substitutions are made as shown in 760.154(A). Where substitute cables are installed, the wiring requirements of Article 760, Parts I and III, shall apply. Types FPLP-CI, FPLR-CI, and FPL-CI cables shall be permitted to be installed to provide 2-hour circuit integrity rated cables.

Table 760.154 Applications of Listed PLFA Cables in Buildings

Applications Cable Type

FPLP & FPLP-CI FPLR & FPLR-CI FPL & FPL-CI

In fabricated ducts as described in 300.22(B) In fabricated ducts Y\* N N

In metal raceway that complies with 300.22(B) Y\* Y\* Y\*

In other spaces used for environmental air as described in 300.22(C) In other spaces used for environmental air Y\* N N

In metal raceway that complies with 300.22(C) Y\* Y\* Y\*

In plenum communications raceways Y\* N N

In plenum cable routing assemblies Y\* N N

Supported by open metal cable trays Y\* N N

Supported by solid bottom metal cable trays with solid metal covers Y\* Y\* Y\*

In risers In vertical runs Y\* Y\* N

In metal raceways Y\* Y\* Y\*

In fireproof shafts Y\* Y\* Y\*

In plenum communications raceways Y\* Y\* N

In plenum cable routing assemblies Y\* Y\* N

In riser communications raceways Y\* Y\* N

In riser cable routing assemblies Y\* Y\* N

In one- and two-family dwellings Y\* Y\* Y\*

Within buildings in other than air-handling spaces and risers General Y\* Y\* Y\*

Supported by cable trays Y\* Y\* Y\*

In any raceway recognized in Chapter 3 Y\* Y\* Y\*

In plenum communications raceway Y\* Y\* Y\*

In plenum cable routing assemblies Y\* Y\* Y\*

In riser communications raceways Y\* Y\* Y\*

In riser cable routing assemblies Y\* Y\* Y\*

In general-purpose communications raceways Y\* Y\* Y\*

In general-purpose cable routing assemblies Y\* Y\* Y\*

Note:

"N" indicates that the cable type shall not be permitted to be installed in the application.

"Y\*" indicates that the cable type shall be permitted to be installed in the application subject to the limitations described in 760.130 through 760.145.

(A) Fire Alarm Cable Substitutions

The substitutions for fire alarm cables listed in Table 760.154(A) and illustrated in Figure 760.154(A) shall be permitted. Where substitute cables are installed, the wiring requirements of Article 760, Parts I and III, shall apply.

Informational Note: For information on communications cables (CMP, CMR, CMG, CM), see 805.179.

Table 760.154(A) Cable Substitutions

Cable Type Permitted Substitutions

FPLP CMP

FPLR CMP, FPLP, CMR

FPL CMP, FPLP, CMR, FPLR, CMG, CM

FIGURE 760.154(A) Cable Substitution Hierarchy.

Part IV Listing Requirements

760.176 Listing and Marking of NPLFA Cables

Non-power-limited fire alarm cables installed as wiring within buildings shall be listed in accordance with 760.176(A) and (B) and as being resistant to the spread of fire in accordance with 760.176(C) through (F), and shall be marked in accordance with 760.176(G). Cable used in a wet location shall be listed for use in wet locations or have a moisture-impervious metal sheath. Non-power-limited fire alarm cables shall have a temperature rating of not less than 60°C (140°F).

(A) NPLFA Conductor Materials

Conductors shall be 18 AWG or larger solid or stranded copper.

(B) Insulated Conductors

Insulation on conductors shall be rated for the system voltage and not less than 600 V. Insulated conductors 14 AWG and larger shall be one of the types listed in Table 310.4(A) or one that is identified for this use. Insulated conductors 18 AWG and 16 AWG shall be in accordance with 760.49.

(C) Type NPLFP

Type NPLFP non-power-limited fire alarm cable for use in other space used for environmental air shall be listed as being suitable for use in other space used for environmental air as described in 300.22(C) and shall also be listed as having adequate fire-resistant and low smoke-producing characteristics.

Informational Note: One method of defining a cable that is low-smoke producing cable and fire-resistant cable is that the cable exhibits a maximum peak optical density of 0.50 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.52 m (5 ft) or less when tested in accordance with NFPA 262-2019, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

(D) Type NPLFR

Type NPLFR non-power-limited fire alarm riser cable shall be listed as being suitable for use in a vertical run in a shaft or from floor to floor and shall also be listed as having fire-resistant characteristics capable of preventing the carrying of fire from floor to floor.

Informational Note: One method of defining fire-resistant characteristics capable of preventing the carrying of fire from floor to floor is that the cables pass ANSI/UL 1666-2012, Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts.

(E) Type NPLF

Type NPLF non-power-limited fire alarm cable shall be listed as being suitable for general-purpose fire alarm use, with the exception of risers, ducts, plenums, and other space used for environmental air, and shall also be listed as being resistant to the spread of fire.

Informational Note: One method of defining resistant to the spread of fire is that the cables do not spread fire to the top of the tray in the "UL Flame Exposure, Vertical Tray Flame Test" in ANSI/UL 1685-2010, Standard for Safety for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables. The smoke measurements in the test method are not applicable.

Another method of defining resistant to the spread of fire is for the damage (char length) not to exceed 1.5 m (4 ft 11 in.) when performing the CSA "Vertical Flame Test — Cables in Cable Trays," as described in CSA C22.2 No. 0.3-M-2001, Test Methods for Electrical Wires and Cables.

(F) Fire Alarm Circuit Integrity (CI) Cable or Electrical Circuit Protective System

Cables that are used for survivability of critical circuits under fire conditions shall meet either 760.176(F)(1) or (F)(2).

Informational Note No. 1: Fire alarm circuit integrity (CI) cable and electrical circuit protective systems may be used for fire alarm circuits to comply with the survivability requirements of NFPA 72-2019, National Fire Alarm and Signaling Code, 12.4.3 and 12.4.4, that the circuit maintain its electrical function during fire conditions for a defined period of time.

Informational Note No. 2: One method of defining circuit integrity (CI) cable or an electrical circuit protective system is by establishing a minimum 2-hour fire-resistive rating for the cable when tested in accordance with ANSI/UL 2196-2017, Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables.

Informational Note No. 3: UL guide information for electrical circuit protective systems (FHIT) contains information on proper installation requirements for maintaining the fire rating.

(1) Circuit Integrity (CI) Cables

Circuit integrity (CI) cables, specified in 760.176(C), (D), and (E), and used for survivability of critical circuits, shall have an additional classification using the suffix "CI." Circuit integrity (CI) cables shall only be permitted to be installed in a raceway where specifically listed and marked as part of an electrical circuit protective system as covered in 760.176(F)(2).

(2) Electrical Circuit Protective System

Cables specified in 760.176(C), (D), (E), and (F)(1), that are part of an electrical circuit protective system, shall be identified with the protective system number and hourly rating printed on the outer jacket of the cable and installed in accordance with the listing of the protective system.

(G) NPLFA Cable Markings

Multiconductor non-power-limited fire alarm cables shall be marked in accordance with Table 760.176(G). Non-power-limited fire alarm circuit cables shall be permitted to be marked with a maximum usage voltage rating of 150 volts. Cables that are listed for circuit integrity shall be identified with the suffix "-CI" as defined in 760.176(F). The temperature rating shall be marked on the jacket of NPLFA cables that have a temperature rating exceeding 60°C (140°F). The jacket of NPLFA cables shall be marked with the conductor size.

Informational Note: Cable types are listed in descending order of fire performance.

Table 760.176(G) NPLFA Cable Markings

Cable Marking Type Reference

NPLFP Non-power-limited fire alarm circuit cable for use in "other space used for environmental air" 760.176(C) and (G)

NPLFR Non-power-limited fire alarm circuit riser cable 760.176(D) and (G)

NPLF Non-power-limited fire alarm circuit cable 760.176(E) and (G)

Note: Cables identified in 760.176(C), (D), and (E) and meeting the requirements for circuit integrity shall have the additional classification using the suffix "-CI" (for example, NPLFP-CI, NPLFR-CI, and NPLF-CI).

760.179 Listing and Marking of PLFA Cables and Insulated Continuous Line-Type Fire Detectors

PLFA cables installed as wiring within buildings shall be listed as being resistant to the spread of fire and other criteria in accordance with 760.179(A) through (H) and shall be marked in accordance with 760.179(1). Insulated continuous line-type fire detectors shall be listed in accordance with 760.179(J). Cable used in a wet location shall be listed for use in wet locations or have a moisture-impervious metal sheath.

(A) Conductor Materials

Conductors shall be solid or stranded copper.

(B) Conductor Size

The size of conductors in a multiconductor cable shall not be smaller than 26 AWG. Single conductors shall not be smaller than 18 AWG.

(C) Voltage and Temperature Ratings

The cable shall have a voltage rating of not less than 300 volts. The cable shall have a temperature rating of not less than 60°C (140 °F).

(D) Type FPLP

Type FPLP power-limited fire alarm plenum cable shall be listed as being suitable for use in ducts, plenums, and other space used for environmental air and shall also be listed as having adequate fire-resistant and low smoke-producing characteristics.

Informational Note: One method of defining a cable that is lowsmoke producing cable and fire-resistant cable is that the cable exhibits a maximum peak optical density of 0.50 or less, an average optical density of 0.15 or less,and a maximum flame spread distance of 1.52 m (5 ft) or less when tested in accordance with NFPA 262-2019, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

(E) Type FPLR

Type FPLR power-limited fire alarm riser cable shall be listed as being suitable for use in a vertical run in a shaft or from floor to floor and shall also be listed as having fire-resistant characteristics capable of preventing the carrying of fire from floor to floor.

Informational Note: One method of defining fire-resistant characteristics capable of preventing the carrying of fire from floor to floor is that the cables pass the requirements of ANSI/UL 1666-2012, Standard Test for Flame Propagation Height of Electrical and Optical-Fiber Cable Installed Vertically in Shafts.

(F) Type FPL

Type FPL power-limited fire alarm cable shall be listed as being suitable for general-purpose fire alarm use, with the exception of risers, ducts, plenums, and other spaces used for environmental air, and shall also be listed as being resistant to the spread of fire.

Informational Note: One method of defining resistant to the spread of fire is that the cables do not spread fire to the top of the tray in the "UL Flame Exposure, Vertical Tray Flame Test" in ANSI/UL 1685-2012, Standard for Safety for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables. The smoke measurements in the test method are not applicable.

Another method of defining resistant to the spread of fire is for the damage (char length) not to exceed 1.5 m (4 ft 11 in.) when performing the CSA "Vertical Flame Test — Cables in Cable Trays," as described in CSA C22.2 No. 0.3-M-2001, Test Methods for Electrical Wires and Cables.

(G) Fire Alarm Circuit Integrity (CI) Cable or Electrical Circuit Protective System

Cables that are used for survivability of critical circuits under fire conditions shall meet either 760.179(G)(1) or (G)(2).

Informational Note No. 1: Fire alarm circuit integrity (CI) cable and electrical circuit protective systems may be used for fire alarm circuits to comply with the survivability requirements of NFPA 72-2019, National Fire Alarm and Signaling Code, 12.4.3 and 12.4.4, that the circuit maintain its electrical function during fire conditions for a defined period of time.

Informational Note No. 2: One method of defining circuit integrity (CI) cable or an electrical circuit protective system is by establishing a minimum 2-hour fire-resistive rating for the cable when tested in accordance with ANSI/UL 2196-2017, Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control and Data Cables.

Informational Note No. 3: UL guide information for electrical circuit protective systems (FHIT) contains information on proper installation requirements for maintaining the fire rating.

(1) Circuit Integrity (CI) Cables

Circuit integrity (CI) cables specified in 760.179(D), (E), (F), and (H), and used for survivability of critical circuits, shall have an additional classification using the suffix "CI." Circuit integrity (CI) cables shall only be permitted to be installed in a raceway where specifically listed and marked as part of an electrical circuit protective system as covered in 760.179(G)(2).

(2) Electrical Circuit Protective System

Cables specified in 760.179(D), (E), (F), (H), and (G)(1), that are part of an electrical circuit protective system, shall be identified with the protective system number and hourly rating printed on the outer jacket of the cable and installed in accordance with the listing of the protective system.

(H) Coaxial Cables

Coaxial cables shall be permitted to use 30 percent conductivity copper-covered steel center conductor wire and shall be listed as Type FPLP, FPLR, or FPL cable.

(I) Cable Marking

The cable shall be marked in accordance with Table 760.179(I). The voltage rating shall not be marked on the cable. Cables that are listed for circuit integrity shall be identified with the suffix "-CI" as defined in 760.179(G). The temperature rating shall be marked on the jacket of PLFA cables that have a temperature rating exceeding 60°C (140°F). The jacket of PLFA cables shall be marked with the conductor size.

Informational Note: Voltage ratings on cables may be misinterpreted to suggest that the cables may be suitable for Class 1, electric light, and power applications.

Exception: Voltage markings shall be permitted where the cable has multiple listings and voltage marking is required for one or more of the listings.

Informational Note: Cable types are listed in descending order of fire performance.

Table 760.179(I) Cable Markings

Cable Marking Type

FPLP Power-limited fire alarm plenum cable

FPLR Power-limited fire alarm riser cable

FPL Power-limited fire alarm cable

Note: Cables identified in 760.179(D), (E), and (F) as meeting the requirements for circuit integrity shall have the additional classification using the suffix "-CI" (for example, FPLP-CI, FPLR-CI, and FPL-CI).

(J) Insulated Continuous Line-Type Fire Detectors

Insulated continuous line-type fire detectors shall be rated in accordance with 760.179(C), listed as being resistant to the spread of fire in accordance with 760.179(D) through (F), and marked in accordance with 760.179(I), and the jacket compound shall have a high degree of abrasion resistance.

Article 770 Optical Fiber Cables

Part I General

770.1 Scope

This article covers the installation of optical fiber cables. This article does not cover the construction of optical fiber cables.

770.2 Definitions

See Part I of Article 100. The definitions in this section shall apply only within Article 770.

Abandoned Optical Fiber Cable. Installed optical fiber cable that is not terminated at equipment other than a connector and not identified for future use with a tag.

Cable Sheath. A covering over the optical fiber assembly that includes one or more jackets and may include one or more metallic members or strength members.

Exposed (to Accidental Contact). A conductive optical fiber cable in such a position that, in case of failure of supports or insulation, contact between the cable's non—current-carrying conductive members and an electrical circuit might result.

Informational Note: See Part I of Article 100 for two other definitions of Exposed: Exposed (as applied to live parts) and Exposed (as applied to wiring methods).

Point of Entrance. The point within a building at which the optical fiber cable emerges from an external wall or from a concrete floor slab.

770.3 Other Articles

Installations of optical fiber cables shall comply with 770.3(A) and (B). Only those sections of Chapter 2 and Article 300 referenced in this article shall apply to optical fiber cables.

(A) Hazardous (Classified) Locations

Listed optical fiber cables shall be permitted to be installed in hazardous (classified) locations. The cables shall be sealed in accordance with the requirements of 501.15, 502.15, 505.16, or 506.16, as applicable.

(B) Cables in Ducts for Dust, Loose Stock, or Vapor Removal

The requirements of 300.22(A) for wiring systems shall apply to conductive optical fiber cables.

(C) Composite Cables

Composite optical fiber cables shall be classified as electrical cables in accordance with the type of electrical conductors. They shall be constructed, listed, and marked in accordance with the appropriate article for each type of electrical cable.

770.21 Access to Electrical Equipment Behind Panels Designed to Allow Access

Access to electrical equipment shall not be denied by an accumulation of optical fiber cables that prevents removal of panels, including suspended ceiling panels.

770.24 Mechanical Execution of Work

Optical fiber cables shall be installed in a neat and workmanlike manner. Cables installed exposed on the surface of ceilings and sidewalls shall be supported by the building structure in such a manner that the cable will not be damaged by normal building use. Such cables shall be secured by hardware, including straps, staples, cable ties, hangers, or similar fittings, designed and installed so as not to damage the cable. The installation shall also conform to 300.4 and 300.11. Nonmetallic cable ties and other nonmetallic cable accessories used to secure and support cables in other spaces used for environmental air (plenums) shall be listed as having low smoke and heat release properties in accordance with 300.22(C).

Informational Note No. 1: Accepted industry practices are described in ANSI/NECA/FOA 301-2016, Standard for Installing and Testing Fiber Optic Cables; ANSI/TIA-568.0-D-2015, Generic Telecommunications Cabling for Customer Premises; and ANSI/TIA 568.3-D-2016, Optical Fiber Cabling and Components Standard.

Informational Note No. 2: See NFPA 90A-2018, Standard for the Installation of Air-Conditioning and Ventilating Systems, for discrete combustible components installed in accordance with 300.22(C).

Informational Note No. 3: Paint, plaster, cleaners, abrasives, corrosive residues, or other contaminants may result in an undetermined alteration of optical fiber cable properties.

770.25 Abandoned Cables

The accessible portion of abandoned optical fiber cables shall be removed. Where cables are identified for future use with a tag, the tag shall be of sufficient durability to withstand the environment involved.

770.26 Spread of Fire or Products of Combustion

Installations of optical fiber cables and communications raceways in hollow spaces, vertical shafts, and ventilation or air-handling ducts shall be made so that the possible spread of fire or products of combustion will not be substantially increased. Openings around penetrations of optical fiber cables and communications raceways through fire-resistant-rated walls, partitions, floors, or ceilings shall be firestopped using approved methods to maintain the fire resistance rating.

Informational Note: Directories of electrical construction materials published by qualified testing laboratories contain many listing installation restrictions necessary to maintain the fire resistive rating of assemblies where penetrations or openings are made. Building codes also contain restrictions on membrane penetrations on opposite sides of a fire resistance-rated wall assembly. An example is the 600-mm (24-in.) minimum horizontal separation that usually applies between boxes installed on opposite sides of the wall. Assistance in complying with 770.26 can be found in building codes, fire resistance directories, and product listings.

Part II Cables Outside and Entering Buildings

770.44 Overhead (Aerial) Optical Fiber Cables

Overhead optical fiber cables containing a non—current-carrying metallic member entering buildings shall comply with 800.44(A) and (B).

(A) On Poles and In-Span

Where outside plant optical fiber cables and electric light or power conductors are supported by the same pole or are run parallel to each other in-span, the conditions described in 770.44(A)(1) through (A)(4) shall be met.

(1) Relative Location

Where practicable, the outside plant optical fiber cables shall be located below the electric light or power conductors.

(2) Attachment to Cross-Arms

Attachment of outside plant optical fiber cables to a cross-arm that carries electric light or power conductors shall not be permitted.

(3) Climbing Space

The climbing space through outside plant optical fiber cables shall comply with the requirements of 225.14(D).

(4) Clearance

Supply service drops and sets of overhead service conductors of 0 to 750 volts running above and parallel to optical fiber cable service drops shall have a minimum separation of 300 mm (12 in.) at any point in the span, including the point of their attachment to the building. Clearance of not less than 1.0 m (40 in.) shall be maintained between the two services at the pole.

(B) Above Roofs

Outside plant optical fiber cables shall have a vertical clearance of not less than 2.5 m (8 ft) from all points of roofs above which they pass.

Exception No. 1: The requirement of 770.44(B) shall not apply to auxiliary buildings such as garages and the like.

Exception No. 2: A reduction in clearance above only the overhanging portion of the roof to not less than 450 mm (18 in.) shall be permitted if (a) not more than 1.2 m (4 ft) of optical fiber cable service drop cable passes above the roof overhang, and (b) the cable is terminated at a through- or above-the-roof raceway or approved support.

Exception No. 3: Where the roof has a slope of not less than 100 mm in 300 mm (4 in. in 12 in.), a reduction in clearance to not less than 900 mm (3 ft) shall be permitted.

Informational Note: For additional information regarding overhead wires and cables, see ANSI/IEEE C2-2012, National Electric Safety Code, Part 2, Safety Rules for Overhead Lines.

770.47 Underground Optical Fiber Cables Entering Buildings

Underground optical fiber cables entering buildings shall comply with 770.47(A) and (B).

(A) Underground Systems With Electric Light, Power, Class 1, or Non-Power-Limited Fire Alarm Circuit Conductors

Underground conductive optical fiber cables entering buildings with electric light, power, Class 1, or non-power-limited fire alarm circuit conductors in a raceway, handhole enclosure, or manhole shall be located in a section separated from such conductors by means of brick, concrete, or tile partitions or by means of a suitable barrier.

(B) Direct-Buried Cables and Raceways

Direct-buried conductive optical fiber cables shall be separated by at least 300 mm (12 in.) from conductors of any electric light, power, non-power-limited fire alarm circuit conductors, or Class 1 circuit.

Exception No. 1: Direct-buried conductive optical fiber cables shall not be required to be separated by at least 300 mm (12 in.) from electric service conductors where electric service conductors are installed in raceways or have metal cable armor.

Exception No. 2: Direct-buried conductive optical fiber cables shall not be required to be separated by at least 300 mm (12 in.) from electric light or power branch-circuit or feeder conductors, non-power-limited fire alarm circuit conductors, or Class 1 circuit conductors where electric light or power branch-circuit or feeder conductors, non-power-limited fire alarm circuit conductors, or Class 1 circuit conductors are installed in a raceway or in metal-sheathed, metal-clad, or Type UF or Type USE cables.

770.48 Unlisted Cables Entering Buildings

(A) Conductive and Nonconductive Cables

Unlisted conductive and nonconductive outside plant optical fiber cables shall be permitted to be installed in building spaces, other than risers, ducts used for environmental air, plenums used for environmental air, and other spaces used for environmental air, where the length of the cable within the building, measured from its point of entrance, does not exceed 15 m (50 ft) and the cable enters the building from the outside and is terminated in an enclosure.

The point of entrance shall be permitted to be extended from the penetration of the external wall or floor slab by continuously enclosing the entrance optical fiber cables in rigid metal conduit (RMC) or intermediate metal conduit (IMC) to the point of emergence.

Informational Note: Splice cases or terminal boxes, both metallic and plastic types, typically are used as enclosures for splicing or terminating optical fiber cables.

(B) Nonconductive Cables in Raceway

Unlisted nonconductive outside plant optical fiber cables shall be permitted to enter the building from the outside and shall be permitted to be installed in any of the following raceways:

Intermediate metal conduit (IMC)

Rigid metal conduit (RMC)

Rigid polyvinyl chloride conduit (PVC)

Electrical metallic tubing (EMT)

Unlisted nonconductive outside plant cables installed in rigid polyvinyl chloride conduit (PVC) or electrical metallic tubing (EMT) shall not be permitted to be installed in risers, ducts used for environmental air, plenums used for environmental air, and other spaces used for environmental air.

770.49 Metal Entrance Conduit Grounding

Metal conduit containing optical fiber entrance cable shall be connected by a bonding conductor or grounding electrode conductor to a grounding electrode or, where present, the building grounding electrode system in accordance with 770.100(B).

Part III Protection

770.93 Grounding, Bonding, or Interruption of Non—Current-Carrying Metallic Members of Optical Fiber Cables

Optical fiber cables entering the building or terminating on the outside of the building shall comply with 770.93(A) or (B).

(A) Entering Buildings

In installations where an optical fiber cable is exposed to contact with electric light or power conductors and the cable enters the building, the non—current-carrying metallic members shall be either grounded or bonded as specified in 770.100 or interrupted by an insulating joint or equivalent device. The grounding or interruption shall be as close as practicable to the point of entrance.

(B) Terminating on the Outside of Buildings

In installations where an optical fiber cable is exposed to contact with electric light or power conductors and the cable is terminated on the outside of the building, the non—current-carrying metallic members shall be either grounded or bonded as specified in 770.100 or interrupted by an insulating joint or equivalent device. The grounding, bonding, or interruption shall be as close as practicable to the point of termination of the cable.

Part IV Grounding Methods

770.100 Entrance Cable Bonding and Grounding

Where required, the non—current-carrying metallic members of optical fiber cables entering buildings shall be bonded or grounded as specified in 770.100(A) through (D).

(A) Bonding Conductor or Grounding Electrode Conductor

(1) Insulation

The bonding conductor or grounding electrode conductor shall be listed and shall be permitted to be insulated, covered, or bare.

(2) Material

The bonding conductor or grounding electrode conductor shall be copper or other corrosion-resistant conductive material, stranded or solid.

(3) Size

The bonding conductor or grounding electrode conductor shall not be smaller than 14 AWG. It shall have a current-carrying capacity not less than that of the grounded metallic member(s). The bonding conductor or grounding electrode conductor shall not be required to exceed 6 AWG.

(4) Length

The bonding conductor or grounding electrode conductor shall be as short as practicable. In one- and two-family dwellings, the bonding conductor or grounding electrode conductor shall be as short as practicable not to exceed 6.0 m (20 ft) in length.

Informational Note: Similar bonding conductor or grounding electrode conductor length limitations applied at apartment buildings and commercial buildings help to reduce voltages that may develop between the building's power and communications systems during lightning events.

Exception: In one- and two-family dwellings where it is not practicable to achieve an overall maximum bonding conductor or grounding electrode conductor length of 6.0 m (20 ft), a separate ground rod meeting the minimum dimensional criteria of 770.100(B)(3)(2) shall be driven, the grounding electrode conductor shall be connected to the separate ground rod in accordance with 770.100(C), and the separate ground rod shall be bonded to the power grounding electrode system in accordance with 770.100(D).

(5) Run in Straight Line

The bonding conductor or grounding electrode conductor shall be run in as straight a line as practicable.

(6) Physical Protection

Bonding conductors and grounding electrode conductors shall be protected where exposed to physical damage. Where the bonding conductor or grounding electrode conductor is installed in a metal raceway, both ends of the raceway shall be bonded to the contained conductor or to the same terminal or electrode to which the bonding conductor or grounding electrode conductor is connected.

(B) Electrode

The bonding conductor and grounding electrode conductor shall be connected in accordance with 770.100(B)(1), (B)(2), or (B)(3).

(1) In Buildings or Structures With an Intersystem Bonding Termination

If the building or structure served has an intersystem bonding termination as required by 250.94, the bonding conductor shall be connected to the intersystem bonding termination.

Informational Note: See Informational Note Figure 800.100(B)(1) for an illustration of the application of the bonding conductor in buildings or structures equipped with an intersystem bonding termination.

(2) In Buildings or Structures With Grounding Means

If an intersystem bonding termination is established, 250.94(A) shall apply.

If the building or structure served has no intersystem bonding termination, the bonding conductor or grounding electrode conductor shall be connected to the nearest accessible location on one of the following:

The building or structure grounding electrode system as covered in 250.50

The grounded interior metal water piping system, within 1.5 m (5 ft) from its point of entrance to the building, as covered in 250.52

The power service accessible means external to enclosures using the options identified in 250.94(A), Exception

The nonflexible metal power service raceway

The service equipment enclosure

The grounding electrode conductor or the grounding electrode conductor metal enclosure of the power service

The grounding electrode conductor or the grounding electrode of a building or structure disconnecting means that is connected to a grounding electrode as covered in 250.32

Informational Note: See Informational Note Figure 800.100(B)(2) for an illustration of the application of the bonding conductor in buildings or structures not equipped with an intersystem bonding termination or terminal block providing access to the building grounding electrode system.

(3) In Buildings or Structures Without Intersystem Bonding Termination or Grounding Means

If the building or structure served has no intersystem bonding termination or grounding means, as described in 770.100(B)(2), the grounding electrode conductor shall be connected to either of the following:

To any one of the individual grounding electrodes described in 250.52(A)(1), (A)(2), (A)(3), or (A)(4).

If the building or structure served has no grounding means, as described in 770.100(B)(2) or (B)(3)(1), to any one of the individual grounding electrodes described in 250.52(A)(7) and (A)(8) or to a ground rod or pipe not less than 1.5 m (5 ft) in length and 12.7 mm (1/2 in.) in diameter, driven, where practicable, into permanently damp earth and separated from lightning protection system conductors as covered in 805.53 and at least 1.8 m (6 ft) from electrodes of other systems. Steam, hot water pipes, or lightning protection system conductors shall not be employed as electrodes for non-current-carrying metallic members.

(C) Electrode Connection

Connections to grounding electrodes shall comply with 250.70.

(D) Bonding of Electrodes

A bonding jumper not smaller than 6 AWG copper or equivalent shall be connected between the grounding electrode and power grounding system at the building or structure served where separate electrodes are used.

Exception: At mobile homes as covered in 770.106.

Informational Note No. 1: See 250.60 for connection to a lightning protection system.

Informational Note No. 2: Bonding together of all separate electrodes limits potential differences between them and between their associated wiring systems.

770.106 Grounding and Bonding of Entrance Cables at Mobile Homes

(A) Grounding

Grounding shall comply with 770.106(A)(1) and (A)(2).

Where there is no mobile home service equipment located within 9.0 m (30 ft) of the exterior wall of the mobile home it serves, the non—current-carrying metallic members of optical fiber cables entering the mobile home shall be grounded in accordance with 770.100(B)(3).

Where there is no mobile home disconnecting means grounded in accordance with 250.32 and located within 9.0 m (30 ft) of the exterior wall of the mobile home it serves, the non—current-carrying metallic members of optical fiber cables entering the mobile home shall be grounded in accordance with 770.100(B)(3).

(B) Bonding

The grounding electrode shall be bonded to the metal frame or available grounding terminal of the mobile home with a copper conductor not smaller than 12 AWG under either of the following conditions:

Where there is no mobile home service equipment or disconnecting means as in 770.106(A)

Where the mobile home is supplied by cord and plug

Part V Installation Methods Within Buildings

770.110 Raceways, Cable Routing Assemblies, and Cable Trays for Optical Fiber Cables

(A) Types of Raceways

Optical fiber cables shall be permitted to be installed in any raceway that complies with either 770.110(A)(1) or (A)(2).

(1) Raceways Recognized in Chapter 3

Optical fiber cables shall be permitted to be installed in any raceway included in Chapter 3. The raceways shall be installed in accordance with the requirements of Chapter 3.

(2) Communications Raceways

Optical fiber cables shall be permitted to be installed in listed communications raceways selected in accordance with Table 800.154(b).

(3) Innerduct for Optical Fiber Cables

Listed plenum communications raceway, listed riser communications raceway, and listed general-purpose communications raceway selected in accordance with Table 800.154(b) shall be permitted to be installed as innerduct in any type of listed raceway permitted in Chapter 3.

(B) Raceway Fill for Optical Fiber Cables

Raceway fill for optical fiber cables shall comply with either 770.110(B)(1) or (B)(2).

(1) Without Electric Light or Power Conductors

Where optical fiber cables are installed in raceway without electric light or power conductors, the raceway fill requirements of Chapters 3 and 9 shall not apply.

(2) Nonconductive Optical Fiber Cables With Electric Light or Power Conductors

Where nonconductive optical fiber cables are installed with electric light or power conductors in a raceway, the raceway fill requirements of Chapters 3 and 9 shall apply.

(C) Cable Routing Assemblies

Optical fiber cables shall be permitted to be installed in listed cable routing assemblies selected in accordance with Table 800.154(c)

(D) Cable Trays

Optical fiber cables shall be permitted to be installed in metal or listed nonmetallic cable tray systems.

770.113 Installation of Optical Fiber Cables

Installation of optical fiber cables shall comply with 770.113(A) through (J). Installation of raceways and cable routing assemblies shall comply with 770.110.

(A) Listing

Optical fiber cables installed in buildings shall be listed in accordance with 770.179 and installed in accordance with the limitations of the listing.

Exception: Optical fiber cables that are installed in compliance with 770.48 shall not be required to be listed.

(B) Ducts Specifically Fabricated for Environmental Air

The following cables shall be permitted in ducts specifically fabricated for environmental air as described in 300.22(B) if they are directly associated with the air distribution system:

Up to 1.22 m (4 ft) of Types OFNP and OFCP

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC installed in raceways that are installed in compliance with 300.22(B)

Informational Note: For information on fire protection of wiring installed in fabricated ducts, see NFPA 90A-2018, Standard for the Installation of Air-Conditioning and Ventilating Systems.

(C) Other Spaces Used for Environmental Air (Plenums)

The following cables shall be permitted in other spaces used for environmental air as described in 300.22(C):

Types OFNP and OFCP

Types OFNP and OFCP installed in plenum communications raceways

Types OFNP and OFCP installed in plenum cable routing assemblies

Types OFNP and OFCP supported by open metal cable tray systems

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC installed in raceways that are installed in compliance with 300.22(C)

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC supported by solid bottom metal cable trays with solid metal covers in other spaces used for environmental air (plenums), as described in 300.22(C)

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC installed in plenum communications raceways, riser communications raceways, or general-purpose communications raceways or supported by solid bottom metal cable trays with solid metal covers in other spaces used for environmental air (plenums), as described in 300.22(C)

Informational Note: For information on fire protection of wiring installed in other spaces used for environmental air, see NFPA 90A-2018, Standard for the Installation of Air-Conditioning and Ventilating Systems.

(D) Risers — Cables in Vertical Runs

The following cables shall be permitted in vertical runs penetrating one or more floors and in vertical runs in a shaft:

Types OFNP, OFCP, OFNR, and OFCR

Types OFNP, OFCP, OFNR, and OFCR installed in:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

Informational Note: See 770.26 for firestop requirements for floor penetrations.

(E) Risers — Cables and Innerducts in Metal Raceways

The following cables and innerducts shall be permitted in metal raceways in a riser having firestops at each floor:

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC installed in:

Plenum communications raceways (innerduct)

Riser communications raceways (innerduct)

General-purpose communications raceways (innerduct)

Informational Note: See 770.26 for firestop requirements for floor penetrations.

(F) Risers — Cables in Fireproof Shafts

The following cables shall be permitted to be installed in fireproof riser shafts having firestops at each floor:

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC installed in:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

Informational Note: See 770.26 for firestop requirements for floor penetrations.

(G) Risers — One- And Two-Family Dwellings

The following cables shall be permitted in one- and two-family dwellings:

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC installed in:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

(H) Cable Trays

The following cables shall be permitted to be supported by cable trays:

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC installed in:

Plenum communications raceways

Riser communications raceways

General-purpose communications raceways

(I) Distributing Frames and Cross-Connect Arrays

The following cables shall be permitted to be installed in distributing frames and cross-connect arrays:

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC installed in:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

(J) Other Building Locations

The following cables shall be permitted to be installed in building locations other than the locations covered in 770.113(B) through (I):

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC installed in:

Plenum communications raceways

Plenum cable routing assemblies

Riser communications raceways

Riser cable routing assemblies

General-purpose communications raceways

General-purpose cable routing assemblies

Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC installed in a raceway of a type recognized in Chapter 3

770.114 Grounding

Non-current-carrying conductive members of optical fiber cables shall be bonded to a grounded equipment rack or enclosure, or grounded in accordance with the grounding methods specified by 770.100(B)(2).

770.133 Installation of Optical Fibers and Electrical Conductors

(A) In Cable Trays and Raceways

Conductive optical fiber cables contained in an armored or metal-clad-type sheath and nonconductive optical fiber cables shall be permitted to occupy the same cable tray or raceway with conductors for electric light, power, Class 1, non-power-limited fire alarm, Type ITC, or medium-power network-powered broadband communications circuits operating at 1000 volts or less. Conductive optical fiber cables without an armored or metal-clad-type sheath shall not be permitted to occupy the same cable tray or raceway with conductors for electric light, power, Class 1, non-power-limited fire alarm, Type ITC, or medium-power network-powered broadband communications circuits, unless all of the conductors of electric light, power, Class 1, non-power-limited fire alarm, and medium-power network-powered broadband communications circuits are separated from all of the optical fiber cables by a permanent barrier or listed divider.

(B) In Cabinets, Outlet Boxes, and Similar Enclosures

Nonconductive optical fiber cables shall not be permitted to occupy the same cabinet, outlet box, panel, or similar enclosure housing the electrical terminations of an electric light, power, Class 1, non-power-limited fire alarm, or medium-power network-powered broadband communications circuit unless one or more of the following conditions exist:

The nonconductive optical fiber cables are functionally associated with the electric light, power, Class 1, non-power-limited fire alarm, or medium-power network powered broadband communications circuit.

The conductors for electric light, power, Class 1, non-power-limited fire alarm, Type ITC, or medium-power network-powered broadband communications circuits operate at 1000 volts or less.

The nonconductive optical fiber cables and the electrical terminations of electric light, power, Class 1, non-power-limited fire alarm, or medium-power network-powered broadband communications circuit are installed in factory- or field-assembled control centers.

The nonconductive optical fiber cables are installed in an industrial establishment where conditions of maintenance and supervision ensure that only qualified persons service the installation.

When optical fibers are within the same composite cable for electric light, power, Class 1, non-power-limited fire alarm, or medium-power network-powered broadband communications circuits operating at 1000 volts or less, they shall be permitted to be installed only where the functions of the optical fibers and the electrical conductors are associated.

Optical fibers in composite optical fiber cables containing only current-carrying conductors for electric light, power, or Class 1 circuits rated 1000 volts or less shall be permitted to occupy the same cabinet, cable tray, outlet box, panel, raceway, or other termination enclosure with conductors for electric light, power, or Class 1 circuits operating at 1000 volts or less.

Optical fibers in composite optical fiber cables containing current-carrying conductors for electric light, power, or Class 1 circuits rated over 1000 volts shall be permitted to occupy the same cabinet, cable tray, outlet box, panel, raceway, or other termination enclosure with conductors for electric light, power, or Class 1 circuits in industrial establishments, where conditions of maintenance and supervision ensure that only qualified persons service the installation.

(C) With Other Circuits

Optical fibers shall be permitted in the same cable, and conductive and nonconductive optical fiber cables shall be permitted in the same raceway, cable tray, box, enclosure, or cable routing assembly, with conductors of any of the following:

Class 2 and Class 3 remote-control, signaling, and power-limited circuits in compliance with Article 645 or Parts I and III of Article 725

Power-limited fire alarm systems in compliance with Parts I and III of Article 760

Communications circuits in compliance with Parts I and V of Article 805

Community antenna television and radio distribution systems in compliance with Parts I and V of Article 820

Low-power network-powered broadband communications circuits in compliance with Parts I and V of Article 830

(D) Support of Optical Fiber Cables

Raceways shall be used for their intended purpose. Optical fiber cables shall not be strapped, taped, or attached by any means to the exterior of any conduit or raceway as a means of support.

Exception: Overhead (aerial) spans of optical fiber cables shall be permitted to be attached to the exterior of a raceway-type mast intended for the attachment and support of such cables.

770.154 Applications of Listed Optical Fiber Cables

Permitted and non-permitted applications of listed optical fiber cables shall be as indicated in Table 770.154(a). The permitted applications shall be subject to the installation requirements of 770.110 and 770.113. The substitutions for optical fiber cables in Table 770.154(b) and illustrated in Figure 770.154 shall be permitted.

Table 770.154(a) Applications of Listed Optical Fiber Cables in Buildings

Applications Listed Optical Fiber Cable Type

OFNP, OFCP OFNR, OFCR OFNG, OFCG, OFN, OFC

Inducts specifically fabricated for environmental air as described in 300.22(B) In fabricated ducts Y\* N N

In metal raceway that complies with 300.22(B) Y\* Y\* Y\*

In other spaces used for environmental air (plenums) as described in 300.22(C) In other spaces used for environmental air Y\* N N

In metal raceway that complies with 300.22(C) Y\* Y\* Y\*

In plenum communications raceways Y\* N N

In plenum cable routing assemblies Y\* N N

Supported by open metal cable trays Y\* N N

Supported by solid bottom metal cable trays with solid metal covers Y\* Y\* Y\*

In risers In vertical runs Y\* Y\* N

In metal raceways Y\* Y\* Y\*

In fireproof shafts Y\* Y\* Y\*

In plenum communications raceways Y\* Y\* N

In plenum cable routing assemblies Y\* Y\* N

In riser communications raceways Y\* Y\* N

In riser cable routing assemblies Y\* Y\* N

In one- and two-family dwellings Y\* Y\* Y\*

Within buildings in other than air-handling spaces and risers General Y\* Y\* Y\*

Supported by cable trays Y\* Y\* Y\*

In distributing frames and cross-connect arrays Y\* Y\* Y\*

In any raceway recognized in Chapter 3 Y\* Y\* Y\*

In plenum communications raceways Y\* Y\* Y\*

In plenum cable routing assemblies Y\* Y\* Y\*

In riser communications raceways Y\* Y\* Y\*

In riser cable routing assemblies Y\* Y\* Y\*

In general-purpose communications raceways Y\* Y\* Y\*

In general-purpose cable routing assemblies Y\* Y\* Y\*

Note: "N" indicates that the cable type shall not be permitted to be installed in the application.

"Y\*" indicates that the cable type shall be permitted to be installed in the application subject to the limitations described in 770.110 and 770.113.

Informational Note No. 1: Part V of Article 770 covers installation methods within buildings. This table covers the applications of listed optical fiber cables in buildings. The definition of Point of Entrance is in 770.2.

Informational Note No. 2: For information on the restrictions to the installation of optical fiber cables in ducts specifically fabricated for environmental air, see 770.113(B).

Table 770.154(b) Cable Substitutions

Cable Type Permitted Substitutions

OFNP None

OFCP OFNP

OFNR OFNP

OFCR OFNP, OFCP, OFNR

OFNG, OFN OFNP, OFNR

OFCG, OFC OFNP, OFCP, OFNR, OFCR, OFNG, OFN

FIGURE 770.154 Cable Substitution Hierarchy.

Part VI Listing Requirements

770.179 Optical Fiber Cables

Optical fiber cables shall be listed and identified in accordance with 770.179(A) through (G) and shall be marked in accordance with Table 770.179. Optical fiber cables shall have a temperature rating of not less than 60°C (140°F). The temperature rating shall be marked on the jacket of optical fiber cables that have a temperature rating exceeding 60°C (140°F).

Table 770.179 Cable Markings

Cable Marking Type

OFNP Nonconductive optical fiber plenum cable

OFCP Conductive optical fiber plenum cable

OFNR Nonconductive optical fiber riser cable

OFCR Conductive optical fiber riser cable

OFNG Nonconductive optical fiber general-purpose cable

OFCG Conductive optical fiber general-purpose cable

OFN Nonconductive optical fiber general-purpose cable

OFC Conductive optical fiber general-purpose cable

(A) Types OFNP and OFCP

Types OFNP and OFCP nonconductive and conductive optical fiber plenum cables shall be suitable for use in ducts, plenums, and other space used for environmental air and shall also have adequate fire-resistant and low smoke producing characteristics.

Informational Note: One method of defining a cable that has adequate fire-resistant and low-smoke producing characteristics is that the cable exhibits a maximum peak optical density of 0.50 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.52 m (5 ft) or less when tested in accordance with NFPA 262-2019, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

(B) Types OFNR and OFCR

Types OFNR and OFCR nonconductive and conductive optical fiber riser cables shall be suitable for use in a vertical run in a shaft or from floor to floor and shall also have the fire-resistant characteristics capable of preventing the carrying of fire from floor to floor.

Informational Note: One method of defining fire-resistant characteristics capable of preventing the carrying of fire from floor to floor is that the cables pass the requirements of ANSI/UL 1666-2011, Standard Test for Flame Propagation Height of Electrical and Optical-Fiber Cable Installed Vertically in Shafts.

(C) Types OFNG and OFCG

Types OFNG and OFCG nonconductive and conductive general-purpose optical fiber cables shall be suitable for general-purpose use, with the exception of risers and plenums, and shall also be resistant to the spread of fire.

Informational Note: One method of defining resistant to the spread of fire is for the damage (char length) not to exceed 1.5 m (4 ft 11 in.) when performing the CSA vertical flame test — cables in cable trays, as described in CSA C22.2 No. 0.3-M-2001, Test Methods for Electrical Wires and Cables.

(D) Types OFN and OFC

Types OFN and OFC nonconductive and conductive optical fiber cables shall be suitable for general-purpose use, with the exception of risers, plenums, and other spaces used for environmental air, and shall also be resistant to the spread of fire.

Informational Note No. 1: One method of defining resistant to the spread of fire is that the cables do not spread fire to the top of the tray in the UL flame exposure, vertical tray flame test in ANSI/UL 1685-2010, Standard for Safety for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables. The smoke measurements in the test method are not applicable.

Another method of defining resistant to the spread of fire is for the damage (char length) not to exceed 1.5 m (4 ft 11 in.) when performing the CSA vertical flame test — cables in cable trays, as described in CSA C22.2 No. 0.3-M-2001, Test Methods for Electrical Wires and Cables.

Informational Note No. 2: Cable types are listed in descending order of fire resistance rating. Within each fire resistance rating, nonconductive cable is listed first because it is often substituted for conductive cable.

(E) Circuit Integrity (CI) Cable or Electrical Circuit Protective System

Cables that are used for survivability of critical circuits under fire conditions shall meet either 770.179(E)(1) or (E)(2).

Informational Note: The listing organization provides information for circuit integrity (CI) cable and electrical circuit protective systems, including installation requirements necessary to maintain the fire rating.

(1) Circuit Integrity (CI) Cables

Circuit integrity (CI) cables specified in 770.179(A) through (D), and used for survivability of critical circuits, shall have an additional classification using the suffix "CI." In order to maintain its listed fire rating, circuit integrity (CI) cable shall only be installed in free air.

Informational Note: One method of defining circuit integrity (CI) cable is by establishing a minimum 2-hour fire resistance rating for the cable when tested in accordance with ANSI/UL 2196-2017, Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control and Data Cables.

(2) Fire-Resistive Cables

Cables specified in 770.179(A) through (D) and 770.179(E)(1) that are part of an electrical circuit protective system shall be fire-resistive cable and identified with the protective system number on the product or on the smallest unit container in which the product is packaged and installed in accordance with the listing of the protective system.

Informational Note No. 1: One method of defining an electrical circuit protective system is by establishing a minimum 2-hour fire resistance rating for the system when tested in accordance with UL Subject 1724, Outline of Investigation for Fire Tests for Electrical Circuit Protective Systems.

Informational Note No. 2: The listing organization provides information for electrical circuit protective systems (FHIT), including installation requirements for maintaining the fire rating.

(F) Field-Assembled Optical Fiber Cables

Field-assembled optical fiber cable shall comply with 770.179(F)(1) through (F)(4).

The specific combination of jacket and optical fibers intended to be installed as a field-assembled optical fiber cable shall be one of the types in 770.179(A), (B), or (D) and shall be marked in accordance with Table 770.179.

The jacket of a field-assembled shall have a surface marking indicating the specific optical fibers with which it is identified for use.

The optical fibers shall have a permanent marking, such as a marker tape, indicating the jacket with which they are identified for use.

The jacket without fibers shall meet the listing requirements for communications raceways in 800.182(A), (B), or (C) in accordance with the cable marking.

(G) Optional Markings

Cables shall be permitted to be surface marked to indicate special characteristics of the cable materials.

Informational Note: These markings can include, but are not limited to, markings for limited-smoke, halogen-free, low-smoke halogen-free, and sunlight resistance.

770.180 Grounding Devices

Where bonding or grounding is required, devices used to connect a shield, a sheath, or non—current-carrying metallic members of a cable to a bonding conductor or grounding electrode conductor shall be listed or be part of listed equipment.

